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JOURNAL OF
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Principles of Furnace Design.

By A. D. Williams

Paper presented Feb. 20, 1917.

Index No. 621.183

Some years ago I noticed the appearance of what looked like stream or flow lines in the burning gases of heating and open-hearth furnaces, and it seemed to me that there must be some law that governed the flow of such gases. One of the peculiarities that I noticed was that the hot gases appeared to float along the top of the flues and passages. Shortly after this I became connected with work in which furnaces were not required and the matter was shelved. About two years ago I learned that Prof. Groume-Grjimailo had published a work on this subject which had been translated into French. I sent for this and found it a very complete exposition of the application of the laws of hydraulics to the flow of incandescent gases. A test of the formulas and an examination of the principles set forth showed that Prof. Groume-Grjimailo had anticipated me by several years and published his theory. The work was so interesting that I secured the permission to translate the work into English.

A more exact title for this paper would be "The Action of Flame in Furnaces as Explained by the Laws of Hydraulics", for it consists of abstracts made from the work of this title by W. E. Groume-Grjimailo, professor of iron manufacturing at the Polytechnic Institute of Petrograd. When Professor Groume-Grjimailo graduated from the Institute of Mines of Petrograd he entered the Salda works of Monsieur Demidow, one of the largest and best metallurgical plants in Russia. Here he worked under a man, Pierre Chicharine, who was entrusted with all the designing of new furnaces and the whipping into shape of those furnaces which did not work in a satisfactory manner. This man, who had but a meager education and could not write his name, was unable to explain his reasons for the changes he made and when questioned, "Why?" generally replied, "It must be made thus, otherwise you arrive at nothing."

After having been at this plant for about 20 years, Prof. Groume-Grjimailo, who during this time had risen to be Director of Works, conceived the idea that each furnace might be represented by a reservoir and that the design of a furnace was a problem in hydraulics. The circulation of the flame or hot gases was analagous to the movement of a light liquid within a heavier liquid. By making white metal sectional models of furnaces which could be enclosed with glass and immersed in a tank of water and circulating colored petroleum through them, he approximated the circulation of the flame through a similar furnace immersed in the atmosphere. This, rendering the action visible to the eye, made it easier to comprehend what took place in the furnace though at the same time it is only a first approximation in the solution of the problem. Objection may also be made to comparing a current of flame with a current of incandescent gas. Prof. Groume-Grjimailo admits this is a well-ground-

ed objection. When the fact that the circulation of the hot gases is a problem in hydraulics has been completely established, then the dense fog of mystery which envelops the designing of furnaces will be cleared away, and it will be time to establish the details. The foregoing was written in 1911 and since then Prof. Groume-Grjimailo, many of the students under him, and others, have investigated various furnaces applying to their study the general laws formulated and developing the constants necessary to the use of the various formulas involved. The results of this work are such that it can be said that a furnace properly proportioned and designed according to these principles will work well and the results can be guaranteed with as little risk as there is in guaranteeing the working of a steam turbine.

In speaking of Prof. Groume-Grjimailo's work, Henry Le Chatelier says, "he brings forward a principle relative to the circulation of the hot gases in a furnace, a very simple principle, but one which has not been thought of before. We think of gases as filling completely, by reason of their absolute elasticity, the vessels which enclose them. And by unconscious induction, but inexact, we conclude that gases, in their circulation traversing a series of enclosures, traverse equally all points of the spaces open to them and sweep uniformly by their current all the passages through which they pass. Perhaps we should not formulate this erroneous principle in such a precise manner, but nevertheless we act as if we believed firmly in this. And it follows, in the construction of furnaces, that very grave errors are made, of which M. Groume-Grjimailo calls our attention to numerous examples."

A comparison may be readily made with those things with which we are familiar. A river which flows in its bed is supported by the earth, bounded upon its sides by the natural surface of the ground. Its upper surface is separated from the air by a horizontal plane whose position is not fixed but which varies with the quantity of water flowing into the stream. The hot gases in a furnace tend to circulate in exactly this same fashion, with this difference, that the plane of separation from the air is below and the cross section of the bed is formed by the roof and walls of the furnace. Neverthless we frequently consider that the flame fills the furnace and heats it uniformly, when in reality it circulates in the upper portion only and does not come in contact with the material placed on the hearth. The utilization of the heat is very inefficient. The stream of flame flows along the roof and carries all of its heat to the chimney.

The formation in the furnace of these streams of hot gas presents other inconveniences, it opposes and makes difficult the completion of combustion. Above a furnace grate we have parallel currents of gas containing an excess of oxygen or an excess of combustible, which must be mixed intimately in order that they may burn. This requires a certain time and they must be mixed at a temperature sufficiently high to permit the reaction of combustion.

In boiler furnaces an arch of refractory materials is frequently built over the furnace, but if it does not form an inverted bell or reservoir in which the hot gases can accumulate and remain for a time the passage of the unburned gas is too rapid and the effect of the arch is entirely imaginary. The work of Prof. Groume-Grjimailo is replete with examples with precise information concerning the works where the observations were made. It is therefore not a purely theoretical work, but is placed before us as a practical treatise concerning things seen.

The fundamental principle of Prof. Groume-Grjimailo's work is that we are surrounded by a liquid ocean, the air. Furnaces we must consider as submerged in this ocean of air.

As the density of this liquid is 770 times less than that of water we do not notice its presence and we habitually fail to take account of it, at the same time we must admit with the author that we are not in a vacuum.

Our error lies in neglecting the part which the ocean of air plays and it is due to this that we have difficulty in comprehending the circulation of the flame in a furnace. But when we commence to take account of the presence of the air then the question of flame circulation becomes very clear.

What is a flame? It is a mixture of gases at a sufficiently high temperature to permit their entering into the reaction called combustion and thus releasing sufficient heat to raise the products of combustion to incandescence.

It is the solid particles of carbon which by their incandescence give the flame that appearance which impresses our imagination and causes us to attribute to it some infernal power. But in reality we may consider this flame replaced by a current of incandescent gas which will be a sufficiently close approximation for our purpose.

We may consider a reverberatory furnace as an apparatus immersed in a liquid, the air, which has a weight of 1 kg. 29 per cubic meter, while in the interior of the furnace a current of incandescent gas circulates, that is to say, a lighter liquid.

As the coefficient of expansion of a gas is 1/273, if we take the specific weight of air at 0° as unity we have:

Temperature	Weight compared with air at 0°	Weight kg. per m^3
0°	1.000	1 kg. 29
273°	0.500	0 kg. 645
546°	0.333	0 kg. 430
819°	0.250	0 kg. 322
1092°	0.200	0 kg. 258
1365°	0.167	0 kg. 215
1638°	0.143	0 kg. 171
1911°	0.125	0 kg. 161

Fig. 1

An idea in regard to the difference in the density of air at the temperature of an open-hearth furnace, 1638°, and air at 0°, may be obtained by comparing the high temperature air to water and the low temperature air to molten iron. The weight of water being 1000 kg. per cubic meter while the weight of molten iron is 6900 kg. per cubic meter.

A furnace in operation may be considered as immersed in an aquarium containing a heavy liquid while its interior is traversed by a lighter liquid and all of the movement of the flame may be compared to that of the light liquid as it floats in the heavier liquid.

The circulation of the flame in the furnace may be shown experimentally in the following manner: A white metal sectional model showing a cross section of the furnace is made. The open sides of this model are closed with pieces of glass. Tube connections are arranged to the various ports and the chimney opening. This model is then immersed in a glass tank filled with water and colored petroleum circulated through it.

Fig. 2 shows the arrangement of the apparatus adopted for use in the lectures at the Polytechnic Institute of Petrograd. The model is a reproduction of a brick kiln at the Motovillikha works. The various tubes are supplied with regulating valves. The highest bottle is filled with colored petroleum and is elevated to give it an initial head. The tank or aquarium, containing the model, is filled with water. A drain is provided by which the petroleum as it rises to the top of the water flows into the lower bottle from which it is returned to the upper bottle by means of a small pump driven by an electric motor so that continuous circulation may be maintained.

By opening the central cooling vent in the roof of the kiln, the model may be utilized to show the action that occurs in the old style of direct or top draft brick kiln.

Upon starting the circulation of the colored petroleum it rises from the fire boxes in a thin stream ascending

the arch of the kiln and escaping at the central vent. The circulation of this colored fluid illustrates the reason that the up-draft kiln gave extremely unsatisfactory results when the ware burned required high temperatures, although it could be utilized in burning low temperature products. Another trouble experienced with this type of kiln was the amount of time consumed in a kiln round. The burning time was long. Upon obstructing the egress of the colored petroleum at the central vent this liquid will accumulate under the roof of the furnace until its depth below the vent supplies a head sufficient to maintain an equilibrium between the amount of liquid flowing into the kiln and the amount passing out at the vent.

This is shown in Fig. 2 where the line of demarcation between the colored petroleum is about midway between the crown of the arch and the sole of the kiln. The lower section of the kiln will only be heated by the eddies and the diffusion which take place between the hot gas in the upper section of the kiln and the relatively cooler gases below. A question that may be brought up here is why the lower section of the kiln is not heated by radiation. Radiation may take place between a hot gas and a cool solid across a gas space at a lower temperature or from a hot solid to a cooler solid across a low temperature gas space. When the kiln is in operation it is filled with a built-up checker work formed by the ware being burnt. The temperature of each layer of this checker must be raised successively before it can radiate heat to the layer below. This radiated heat will tend to raise the temperature of the cooler gases which will rise carrying the heat back to the high temperature zone.

By further obstruction of the open vent the line of separation between the hot gases and the cooler gases may be forced down to the sole of the kiln. This manner of working enables certain wares to be burnt in this type of kiln, but it does not work in the most satisfactory manner and cannot be utilized for high grade ware. The flame has a tendency to rise to the opening in the arch and the temperature is not equalized by the eddy currents that form. These currents are very feeble as they depend upon the temperature difference that exists between the gases at the sole level and those under the roof of the furnace. Kilns of this type

FIG. 2

were formerly in universal use but they have been gradually replaced by the down draft kiln, although there are many direct draft kilns still in operation.

When the vent in the top of the kiln is blocked up the colored petroleum soon fills the kiln and passes out through the lower flue and up the chimney. With this method of operation the hottest gases rise to the roof and a high temperature line starting at the roof gradually descends to the sole of the kiln giving a practically uniform burn. In this type

of kiln there will be a very small temperature difference in the height of the kiln and the reaction of combustion may be completed with very little free oxygen. There are no definite high temperature centers.

When down-draft kilns are used to burn ware that requires extremely high temperatures, say 1550 to 1600 degrees, which are practically the highest temperatures obtainable with direct firing, the air supply must be cut down so close to the theoretical limit that complete combustion cannot be obtained. Under such circumstances the waste gases leaving the kiln are a lean producer gas and are so hot that secondary combustion will occur wherever these hot gases come in contact with the air. This is the explanation of the plume of flame that is usually seen on kiln chimneys.

The basis upon which we compare the current of flame in a furnace to an inverted river may be made more clear by reverting to a couple of illustrations drawn from elementary physics.

Carbon dioxide gas is heavier than air, weighing 1 kg. 977 per cubic meter. It is possible to pour it from one beaker to another in the manner shown at the left. Hydrogen on the other hand is lighter than air, weighing 0 kg. 0.090 per cubic meter and may be transferred from one vessel to another in the manner shown at the right. Naturally, owing to the diffusibility of gases these two experiments must be carefully performed in a place where the air currents can be kept away. The experiment with the hydrogen illustrates the inverted river simile which has been used for the flow of the hot gases in a furnace and shows that it is only necessary to confine the current of gas at the top and the two sides. That the lower or fourth side will be formed by the flowing gases and its position will be determined by the quantity of the gas flowing. The conditions shown are practically those that exist in most furnaces.

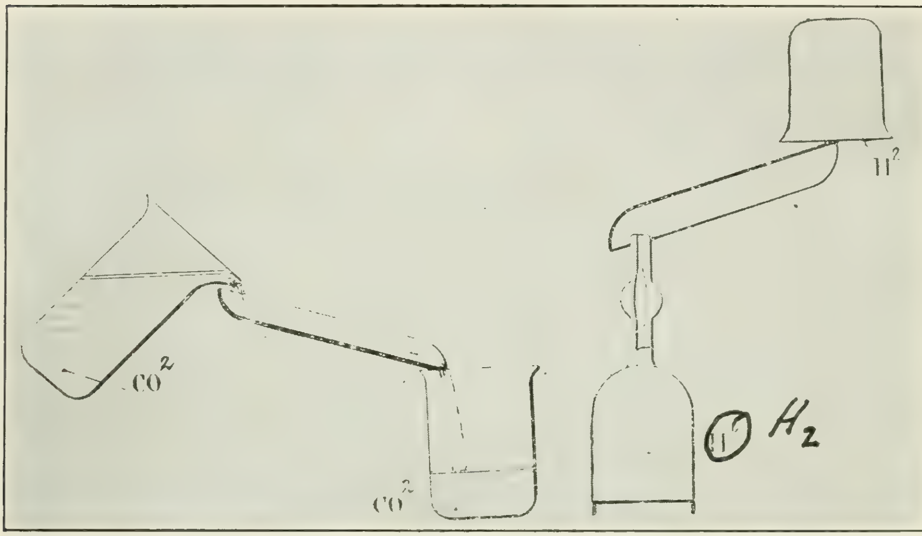

FIG. 3

This theory would be erroneous if the flue carrying the waste gases away from a battery of boilers were found to be completely filled with the flowing gases regardless of the number of boilers in service. However, in a flue correctly proportioned, with four

boilers in service the lower surface of the current of gases will be found in the neighborhood of the line *AA* (Fig. 4) while when only one of the boilers is in use the lower surface of the gas current will be in the neighborhood of *BB* (Fig. 4). In this last case only one-fourth the quantity of waste gases is flowing and the thickness or depth of the gas current is 0.4 of that when all of the boilers are in service or in the ratio of $1 \div \sqrt[3]{4^2}$. While in the space *AABB* there is scarcely any circulation of gases.

It is evident that as in a river the depth of the stream is a function of the quantity of water flowing, so in a current of hot gases the thickness of the stream will depend upon the volume passing through the flue or passage.

The weight of the gaseous products of combustion varies from 1 kg. 25 to 1 kg. 35, while the weight of the air is 1 kg. 29, per cubic meter. Therefore all of the computations may be greatly simplified, without introducing any serious error, if the waste gases are assumed to weigh the same as air. The coefficient of expansion of gases by heat is 1/273 and the weight of air at any temperature may be found by the formula

$$p = \frac{1.29}{1 + a\,t}$$

in which p = the weight of air at t° per cubic meter; a = 1/273; t = temperature of the air.

The hydrostatic pressure in kilogrammes per square meter at a point in an enclosure filled with incandescent gas, situated at a distance *H* above its lower surface, is equal to the difference, *W*, between the weight of a cubic meter of air and the weight of a cubic meter of the incandescent gas multiplied by the height, *H*.

$w = H\,W.$

w = hydrostatic pressure in kg. per m².

$w = 1.29 - p.$

A number of examples may be cited to show that this hydrostatic pressure exists: The hot air register used to admit hot air from a furnace to a room; the upper peep holes to the regenerators which are on air or gas; the upper portion of many heating furnace doors. This jet of air or gas occurs not because of its temperature, but because it is lighter than the outside air. A similar phenomenon is that which causes the gas pressure in city mains to be higher upon the high ground and the top floors of

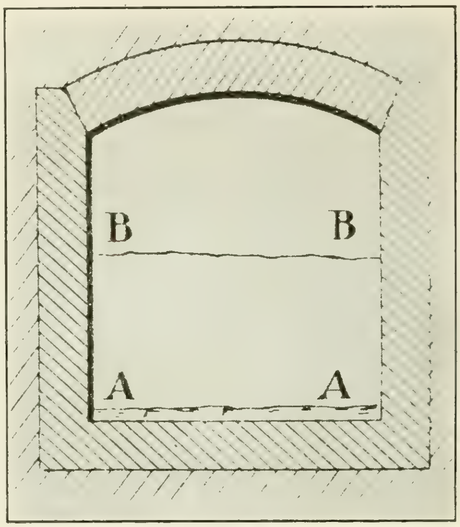

Fig. 4

buildings than it will be on the low ground or in the basement.

Draft of metallurgical furnaces: It has been believed for a long time that furnaces into which the air was not forced drew in their air supply under the influence of the draft of their chimneys. This is due to a poor interpretation of what takes place.

A first principle which we must remember is that those furnaces which are not provided with working doors or charging openings, may operate, in some manner by the draft of their chimney. Such furnaces are boilers enclosed on all sides in their brick setting, crucible furnaces closed very

nearly hermetically, iron tube blast furnace stoves, Cowper and similar stoves, etc.

All furnaces which are provided with working doors to their hearth, such as reverberatory furnaces, melting furnaces, puddling furnaces, brick kilns, open-hearth furnaces, etc., do not operate by chimney draft. For these furnaces the chimney merely serves to draw the products of combustion from the hearth, and it is unnecessary to construct the colossal chimneys which are frequently built.

This last may be readily established with a properly designed reverberatory furnace when it is in operation. As the doors are not hermetically sealed to the walls (Fig. 5) a jet of flaming gas escapes at the top of the door. If a flaming torch is brought to this point the flame tends to incline away from the furnace, but if this torch be brought to the lower edge of the door the flame will tend to be drawn into the furnace. This shows that in the vicinity of the roof of the furnace the gas pressure is slightly above that of the atmosphere while at the sole of the furnace the gas pressure is less than the atmosphere.

If three openings are made in the wall of a furnace as shown in Fig. 6, there will be a jet of flame at the upper opening and the lower opening will draw in air. The middle opening will be neutral, but as the conditions in the furnace change slightly from time to time during a portion of the time this opening will draw air into the furnace and at other times a jet of flame will escape from it. These simple observations show that the metallurgical furnaces work with a pressure that is on the average equal to that of the atmosphere. This may also be shown by manomometer observations. Such a furnace will not work regularly and uniformly if the pressure within it is less than that of the atmosphere as under such conditions there will be an inflow of air through the working door which will counterbalance the draft of the chim-

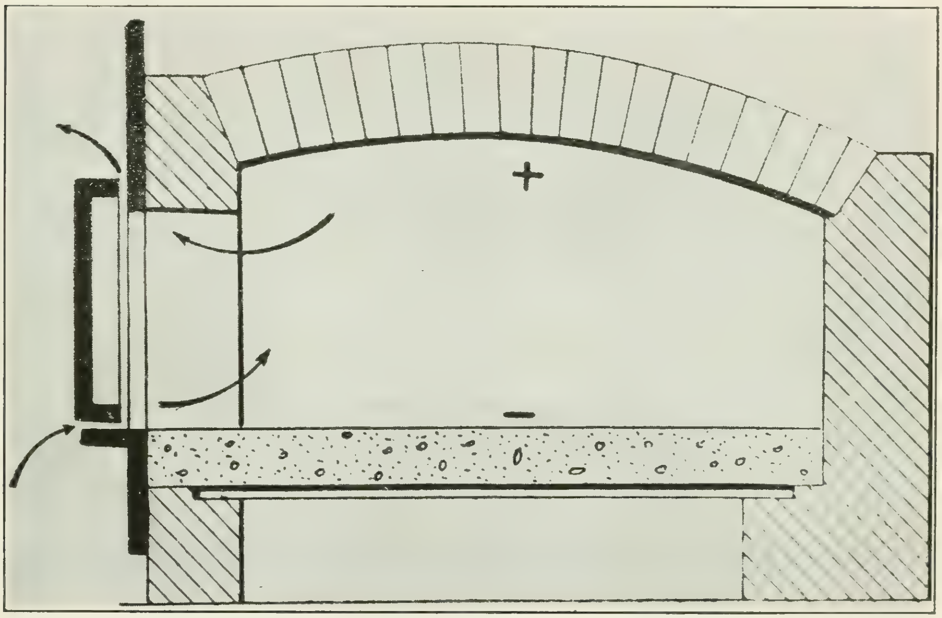

FIG. 5

ney, this cold air will lower the temperature within the furnace, chill the charge and have a very bad effect generally.

In many cases it is possible to work a badly designed furnace of this type by forcing the firing to such an extent that the pressure in the hearth is maintained and one of the signs of such inefficient design is the flames jetting out at the lower part of the doors.

With this type of furnace the chimney simply acts to carry off the waste gases and dispose of them where they will not be a nuisance. The pressure of the gas in the furnace will be slightly positive, nearly zero. The fire box acts to pump in the elements necessary for combustion.

Following these demonstrations that the gases flowing through the various passages of a furnace followed the laws of hydraulics, Prof. Groume-Grjimailo interested Prof. Yesmann in the matter and he developed formulas based upon those used for the flow of water which with suitable constants have been found to permit very accurate predictions in regard to the workings of a furnace. These formulas have been used in analyzing a number of existing furnaces of the reverberatory type. A feature of this work was that it developed the fact that many of those parts to which empiricism had attributed great importance could be altered within wide limits without any effect upon the working of the furnace while seemingly unimportant portions of the furnace played a very important role in its operation. That proper designing frequently made a difference of between 25 and 30 per cent in the fuel consumption. It was also found that the formulas developed and the proportional methods used in the designing of furnaces were, comparatively, of little value.

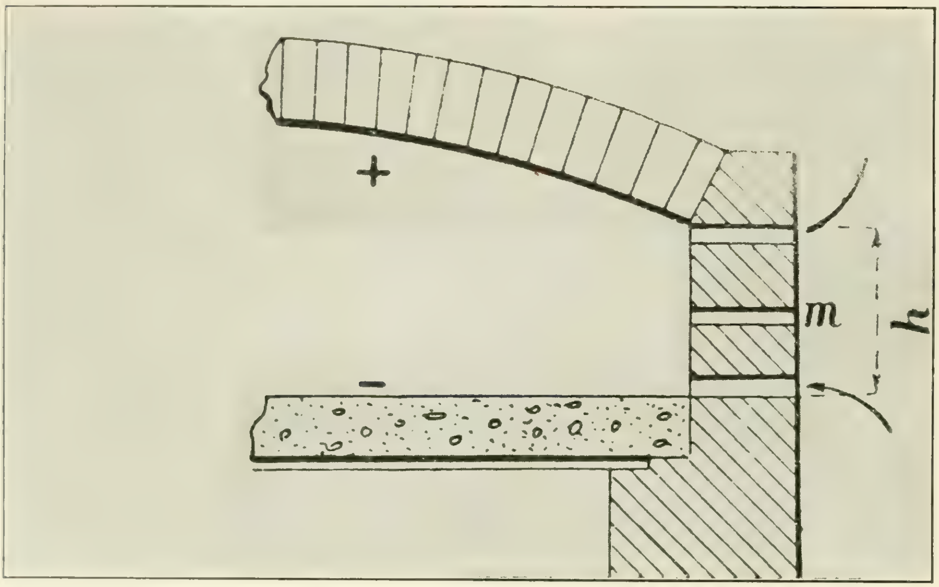

Fig. 6

In establishing the dimensions for a new furnace the factor which determines the size of the sole is the capacity, that is, the amount of material which must be in the furnace at one time or the tonnage to be heated in a unit time. The height of the roof will be governed by the height to which the material may be piled

in some cases and in others by the volume of gas and the time it must remain in the furnace, as well as by the flame temperature. The roof must also be so designed that the flaming gases will not be forced down on cold material. The flame temperature may be calculated fairly closely by the methods developed by Damour, Le Chatelier and Mallard. It is also desirable to know the composition of the gases of combustion or more particularly the amount of excess air in these gases. A good coal burned without excess air has a theoretical flame temperature of 2050 degrees. The flame temperature actually developed may be as high as 1400 to 1450 degrees with 70 per cent excess air and it will drop to 1250 degrees with 100 per cent excess air.

For design purpose furnaces may be placed in five main classes, under each of which there will be subclasses:

First: Small, direct-fired furnaces in which the gases remain but a fraction of a second. The material is charged cold, and the combustion depends upon cold air and the fuel bed is thin. The furnace under a steam boiler is an example of this type. The combustion is comparatively rapid and effected under unfavorable conditions. It is questionable whether properly designed boiler furnaces are worth while except for large units, as the governing temperature is so low that almost anything may be made to work, where smoke is not a nuisance.

Second: Direct-fired furnaces with arch over grate, thick fuel bed. Natural or forced draft (sometimes introduction of secondary air), rapid combustion under comparatively favorable conditions, and can be worked with 50 per cent excess air. Some stoker-fired boilers with high fire boxes approximate this condition. From 70 to 200 kg. of coal may be burned per square metre of grate. Furnaces of this type are reverberatory matting and heating furnaces, puddling furnaces, glass furnaces, reheating furnaces.

Third: Furnaces fired by producer gas with 150 per cent to 170 per cent air supply. Most gas-fired reheating furnaces fall in this class.

Fourth: Open-hearth and similar furnaces, gas-fired where the secondary air supply is 125 per cent to 150 per cent of the theoretical.

Fifth: Furnaces fired with the theoretical air supply or with a very slight excess of air in which the gases travel slowly. Some brick kilns, tempering furnaces and reheating furnaces fall in this class. The furnaces may be gas-fired or in some cases form a continuation of the gas producer.

The amount of gas resulting from the combustion of a coal will depend upon its chemical composition. A good grade of coal will require approximately $8 m^3$ 70 of air theoretically and will produce about $9 m^3$ o4 of waste gases per kilogramme. The waste gases with different amounts of excess air are:

Theoretical air supply....	$9 m^3$ 04
50 per cent excess air....	$13 m^3$ 26
75 per cent excess air...	$15 m^3$ 39
100 per cent excess air...	$17 m^3$ 75

Another important factor is the length of time the gases remain in the furnace. This varies within wide limits from a small fraction of a second up to ten seconds. This time is governed by the temperature at which the gases leave the hearth and the flame temperature, in other words the temperature drop per second. This drop is as follows:

Open-hearth furnaces, 200 degrees per second.

Reheating furnaces gradual, 150-200 degrees per second.

Reheating furnaces, 100-150 degrees per second.

Brick kilns, 80 degrees per second.

The values have not been finally established. Exact knowledge concerning the temperature drop per second for all species of furnaces can only be established by observations.

upon correctly constructed furnaces. This is the principal difficulty.

The fall in temperature per second is a function.

(*a*) Of the radiation loss. This depends upon the radiating surface, the conductability of the walls and the flame temperature. In other words it is peculiar to each type of furnace.

(*b*) Of the heat absorption capacity of the material heated. That is a furnace charged with hot metal or ingots will work differently from one charged with cold material. The drop in temperature per second will be much higher in the second furnace than it will in the first. The first furnace will have a more rapid gas flux and the second will require a greater quantity of gas. A furnace serving a roll train must have a heating capacity which will keep the mill full. For rapid and continuous work the time of the gas in the furnace will be cut down while where the work is discontinuous the time of the gas in the furnace may be increased.

Knowing the working conditions of the furnace to be designed the procedure is as follows:

1. The volume of the heating chamber is calculated.

2. The volume of gas obtained per kilogramme of coal burned under the service conditions is computed.

3. The theoretical combustion temperature of the fuel with an assumed excess of air is computed.

4. The temperature at which the waste gases are to leave the heating chamber is determined. This is approximately as follows: Open-hearth furnaces, 1600 degrees; puddling and melting furnaces, reverberatory, 1250 degrees; soaking pit furnaces, 850 degrees; heating furnaces, 1000 degrees; glass melting furnaces, 1200 degrees.

5. Knowing the temperature of the flame and the temperature of the waste gases the total temperature drop in the furnace is established. This divided by the drop in temperature per second gives the time the gas should remain in the heating chamber.

6. The capacity of the heating chamber divided by the time the gases remain in it gives the volume of gas per second Qt. at the average temperature of the furnace. From this the quantity of gas at 0° = Qo is established and from this the weight of fuel burned per second and per 24 hours can be arrived at.

7. Knowing Qt. as determined above the principal dimensions of the furnace may be computed. The velocities of the gases in different parts of the furnace are computed and from this the necessary hydrostatic head required to supply this velocity can be arrived at; this determines the height from the bottom of the grate to the sole of the furnace for natural draft or the blower pressure required. We can also compute the height of the chimney and the sizes of various flues.

DISCUSSION

Frederick Peiter.—When you showed the cut of the smoke flue, you had two lines, *"AA"* and *"BB"*, in which the lower line, *"AA"*, represented the smoke flue. I would like to have a little light on what the state of the substance below the line *"BB"* is. We can hardly say that it is static, no movement in it. If there is a movement there, and it is separated simply by eddy currents, there must be some current, because it would hardly be likely it would move in the opposite direction.

A. D. Williams.—It is rather difficult to determine exactly where that line of demarcation occurs. The upper portion of the flue shows waste gases moving toward the chimney, but with a diminished velocity. In the lower portion of the flue the gases are cold or chilled and show very little motion, similar to backwater in a river.

FREDERICK PEITER.—Well, do I understand then that they are also moving, but at a very much lower velocity?

A. D. WILLIAMS.—At a very much lower velocity.

FREDERICK PEITER.—And there is no variation?

A. D. WILLIAMS.—There is no sharp line of demarcation, but the gases in the lower part of the flue are much cooler than those in the upper part of the flue.

FREDERICK PEITER.—But there must be a certain relation from the top to the bottom. One could hardly say that it would stop at one point.

A. D. WILLIAMS.—No.

FREDERICK PEITER.—There is another question I would like to ask. In one slide you brought out three tubes, the top, the bottom and the one marked "*M*". You say that there is a high pressure at the top of the furnace, at the middle of the height of the furnace it is about neutral, and at the lower a slight suction exists. You say that the stack simply acts as a scavenger there. In other words, the gas travels down as in a reverberatory furnace. What is the pressure in the top due to if it is not due to the hydrostatic head?

A. D. WILLIAMS.—It is due to the hydrostatic head of the hot gases. This head is the difference between the weight of a column of incandescent gas and a column of cold air of the height of the furnace.

FREDERICK PEITER.—In other words it is simply a stack effect right through.

A. D. WILLIAMS.—Yes. Almost all of the phenomena of the furnace are due to the small stack heads at different points. A head equivalent to one metre in height of a gas will give it a velocity of 4 m 43 per second. With gases at 1000 degrees this head would be equivalent to about 0 m/m 3.

A. D. WILLIAMS.—There is an interesting effect due to these hydrostatic heads in the open-hearth furnace. In these furnaces the pressure in the hearth is practically equal to that of the atmosphere in order that there may be no cold air drawn into the hearth when the doors are opened. The gases pass through the hearth at a high velocity. This velocity is due to the height of the regenerators and the flues leading to the ports and is sometimes as much as 50 metres per second. With these furnaces the only function of the stack is to remove the waste gases from the regenerators which are heating up. The bath of molten steel lies below the level of the ports. These ports are inclined to direct the flame down on the bath. A high velocity of the entering gas and air is necessary in order that the flame may reach the bottom of the furnace when they are making bottom or repairs. The bottom has to be sintered in place before the furnace is placed in operation and between heats it is necessary to repair the bottom before the furnace can be again charged. The angle of inclination of the ports is a function of the height of the regenerators and the temperatures to which the incoming air and gas are raised.

FREDERICK PEITER.—I might mention in connection with this that we had a continuous heat furnace at a steel works I was formerly connected with. We had considerable trouble with it. It was of the continuous type, about 70 feet long, 30 feet across, and about 5 feet high. We were unable to get any heat out of the furnace at all. Finally we dropped the arches in that furnace a distance of several feet, and introduced secondary air; then we got results. Until I talked to Mr. Williams here, I did not know why we got the results. We got results for two reasons: First, we got the hot gases down where they filled the furnace, and in the second place we got more perfect combustion. Although we remedied our trouble, we never knew why we remedied it.

R. B. CLAPP.—I would like to step outside of the steel business a minute and refer to boiler settings and boiler

furnaces. Would it not seem reasonable that you would get a better heat content, perhaps, in your furnace chamber under the boiler if you would make the stack draw the hot gases from the bottom instead of the top, and hold the heat in the top?

A. D. Williams.—You naturally would; but the trouble with most boiler furnaces is that they are from four to ten feet too low, that is, the boiler is much too close to the grate. The best boiler furnace that I know of is that of the Delray type boilers, in which there is a distance from the grate to the top of the brick cross wall protecting the mud drum of from 12 to 14 feet. This is the point where the first tubes are exposed. Above this there is a clear height of about 20 feet to the point where the gases commence to divide off toward each side. Some of the older types of Babcock & Wilcox boilers have been raised and reset with higher combustion chambers. At the Cedar Avenue power house, this city, I think, such boilers have been raised until there is a clear height of 10 to 15 feet between the stoker and the lowest row of tubes. I think if they had raised them four or five feet more they would have done better. By raising boilers of this type so there is sufficient space to build a brick arch over the fire designed in such a manner that it will hold the hot gases until combustion is complete and taking the waste gases away at the bottom of the setting the conditions for combustion would be greatly improved. The two-pass boiler furnace is a great deal better than the three-pass furnace. In boiler furnaces the conditions of combustion are extremely unfavorable, due to the gases being chilled below their igniting temperature before they have a chance to burn. The result is soot deposits on the tubes. The average boiler, in fact, is a much better machine for making lamp black than it is for burning coal and absorbing its heat. The way lamp black is made is to chill the gas flame below the igniting temperature by impinging it against an iron plate that carries off the heat. The result is a heavy deposit of soot or lamp black on the plate. This carbon deposit is scraped off and cooled. Soot blowers and similar appliances would be unnecessary with properly designed boiler settings.

R. H. Danforth.—I might say in corroboration of Mr. Williams' statement that the New York Edison Company, some ten years ago, raised some B. & W. boilers, comparatively old type, about six feet. Normal plant operation before they did this gave them a boiler efficiency of about 58 per cent. That is the thermal efficiency of the unit. After they had completed the adjustment and got their firemen used to the new conditions, they got a running efficiency from day to day of about 68 to 70 per cent. As a result of that the B. & W. people are now recommending that their furnaces be made as high as possible, and when they designed these special boilers for the Delray plant, over in Detroit, it gave them a furnace height of about 20 feet. They are the same type of boilers and settings that we have out in the Muny plant in Cleveland, except that in the Muny plant the boilers are smaller units.

A. D. Williams.—In connection with some power plant work recently the question was whether to use the Delray boiler or to use the ordinary Stirling boiler. The time of delivery was important, and it was suggested that two Stirling boilers could be placed in one setting with the fire box underneath, making an arrangement similar to that of the Delray type of boiler. There is another boiler, similar to the Delray boiler, but the only trouble with it is the central drum is set lower.

I knew of the raising of the boilers at the New York Edison plant. I was in New York at that time, connected with the New York Central Railroad

on their electrification work. In working out the electric plants they wanted to set the boilers right down on top of the stokers but finally we managed to get a height of six feet between the stoker and the lower tubes with a coking arch that sloped down toward the grates. Roney stokers were placed under these boilers and they did very well. In some cases these boilers were forced up to 350 per cent of their rated capacity. Since then, I believe, Taylor stokers have been placed under the boilers.

R. B. CHILLAS.—What is the limit on the height that you can go?

A. D. WILLIAMS.—Well, I do not know. The type *"W"* or Delray boiler gives about the best combustion results of any boiler I know of. They are running very high CO_2, very little O_2, and getting fairly good stack temperatures. I think the total height, from the stoker to the central drum, is about 32 feet, and I would not be at all surprised if five or six feet more would help. The difficulty with high boiler settings is head room conditions every time one tries to set a boiler properly. It cannot be done where the space has not been provided. Most buildings are so designed that it is impossible to set a boiler in the basement without digging below the floor line, which is objectionable in some ways. The boilermaker, in trying to meet such demands, gets out a setting plan with a grate too close to the boiler.

R. H. DANFORTH.—Dutch oven?

A. D. WILLIAMS.—The dutch oven, as usually built, is a snare and a delusion. The best way to build a dutch oven would be to place it off to one side of the boiler, then let the gases pass down by the boiler instead of rising through it.

R. H. DANFORTH.—Then you would lose your radiant effect.

A. D. WILLIAMS.—Well, is that radiant effect very large with a boiler?

R. H. DANFORTH.—It is about 70 per cent of the total heating in a locomotive boiler.

A. D. WILLIAMS.—In a locomotive boiler that may be true.

R. H. DANFORTH.—And in most low-set boilers it is 35 to 40.

A. D. WILLIAMS.—That may be possible, but on waste heat boilers set over puddling furnaces and other waste heat boilers. The ones I am best informed about are some that are set in series with a copper smelting reverberatory furnace where the distance from the fire box to the boiler is considerably over 100 feet. I do not think they get very much radiation in that case. The heat is carried by the gases. At first one boiler was set between the furnace and the stack but as this did not reduce the waste gas temperature sufficiently a second boiler was set in series with the first. This increased their evaporation and reduced the stack temperature considerably. These boilers are installed at the Anaconda Smelter.

R. H. DANFORTH.—That is very true, but the situation is not exactly the same as when you are burning fuel under your furnace directly. You are talking about waste heat boilers? There you do not get any radiant effect at all, because you have no fuel to burn. There you are getting only that portion of heat from your fuel which is communicated from the hot gases by conduction and convection. And as I say, in some of the types of boilers we use commercially, that only amounts to from 30 to 60 per cent. In a B. & W. marine type boiler, which is the type with which I am most familiar, we get in the ordinary settings about seven feet of head room in the furnace chamber as a maximum, about five feet at the low end, and if we do not cover over the furnace with fire brick, suspended from the tubes, we get very poor operation; that is, if we put the fire brick over the first row of tubes; but if we suspend it under the first row of tubes so that we have a fire brick covering over

the furnace chamber, the fire brick gets heated up sufficiently by the radiant heat so that it completes the combustion. It is almost equivalent, although not quite, to increasing the height of your furnace, because it keeps things hot.

A. D. WILLIAMS.—It acts as a heat reservoir. It radiates or reflects the heat from the incandescent fuel and in that way promotes combustion.

R. H. DANFORTH.—But in that type of furnace the effect is not as marked as it is in some of the land boiler furnaces on account of the fact that the gases stay in the furnace only about seven-tenths of a second.

A. D. WILLIAMS.—Just about, and a shorter time in some furnaces. I have seen forced draft on naval boilers where it pretty nearly blew the fire out the top of the stack. I do not know how much coal was burned. The questions of how much coal was burned and economy were of secondary importance. The main question was steam pressure and engine revolutions.

R. H. DANFORTH.—Those B. & W. naval boilers, with the seven-foot clear head room in their furnace chambers, will burn when they are forced about 125 pounds of coal per square foot of grate per hour, and they will burn that with somewhere around 65 to 68 per cent efficiency if they are properly fired, but they can be very easily indeed knocked down to about 45 per cent of efficiency by green firemen. They are very sensitive, and that is due largely to the fact that the green fireman does not know how to control his fires so as to give the gases a chance to completely burn before they leave the furnace chamber.

A. D. WILLIAMS.—There was a time when the Cramp Shipbuilding Company, and a few others were getting pretty big premiums by developing a speed in excess of the contracted rate on war vessels. They had a special crew of stokers that they put on these ships for their acceptance trials, and they were "pippins". I had two of them on a boiler trial once, and you could put a dollar bill flat on the floor about 15 feet away and that stoker would land a shovelful of coal so that the bill was entirely covered. I tried it twice, and then concluded that two dollars was enough to pay for that knowledge. I naturally did not believe it could be done, but he would land that coal dead. It would hardly scatter at all.

R. H. DANFORTH.—Of course, there is one thing in connection with the firing of these low type furnaces which Mr. Williams has not brought out at all, and which is directly contrary to the usual land practice, although I think it would be a good thing if we could incorporate it in the land practice, and that is, with a furnace having five or six feet of head room, the only way to get satisfactory thermal efficiency out of it (proper combustion) is to run a fuel bed of about five or six inches thickness instead of 10 or 12. That means the fireman must be at the door all the time and fire half shovels full perhaps every three or four seconds on some spot in your furnace. That is why the torpedo boats—not the modern ones, because they are fired with fuel oil—but the old coal type torpedo boats carry a crew of about 125 men, of whom about 60 are stokers.

A. D. WILLIAMS.—They run about one man to every fire door and one relief to every two fire doors.

R. H. DANFORTH.—The routine in the navy fire room, when they are running under forced draft and full speed is to have three firemen for each furnace. The furnaces are two door furnaces, and they keep one man on each furnace door. The third man opens and shuts the door for the man that is firing, and they run that way for approximately 30 minutes at a time, and the fireman that has been opening and shutting doors for the other two men takes a turn on the shovel, and the one that has been working the longest opens and

shuts the doors. That is the only way they can carry it through.

A. D. WILLIAMS.—All the coal is brought in so that the stoker has practically nothing to do but fill his scoop, swing around and throw in the coal.

R. H. DANFORTH.—He moves about four feet.

A. D. WILLIAMS.—Yes. It is dumped right in back of him. I have seen them carry a forced draft of, I think it was six inches of water in the stoke hold. Of course with oil fuel one can get very nearly any boiler output desired.

R. H. DANFORTH.—There again one must have the height of combustion chamber to get efficiency.

A. D. WILLIAMS.—Yes, you have to throw the oil into a hot chamber, otherwise the flame would be checked and would soot up the whole heavens. There is nothing I know of that can make more soot than a torpedo boat. I got caught once in the lee of the Cushing, and I guess they had a green crew on.

R. B. CHILLAS.—That must be the smoke screen, you are speaking of, that is used now for concealment purposes.

A. D. WILLIAMS.—That is what they do it for. On all of those boats they are taught how to arrange their fires to get the greatest amount of smoke. I am much obliged to you for bringing that out because it is important.

Electric Japanning.

By C. D. Carlson*

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The term japanning refers principally to the covering of wood or metal with a coat of black varnish and hardening the same by baking in an oven. The process as used today can be regarded as a step between painting and porcelain enameling.

Records show that as far back as 392 B. C. the Japanese were cultivating a tree known as Rhus-vernicefera, belonging to the same family as the sumach. This tree was tapped when about ten years old, and a grayish white juice drawn off which, when applied to pieces of wood, oxidized, turned black, and formed a very glossy and smooth lacquer. In later periods we find, from time to time, some mention of this same work being done by the Japanese, but it is not until the fifteenth century that any record of this art is to be found in Europe. In the seventeenth century, the English and Dutch had made it into a regular profession, giving it the name "Japanning".

The early Japanese product was costly and took considerable time, but the articles finished under this method were found to withstand the elements for years, holding their luster and adhesiveness. When Europe took up the work, a substitute for the old Japanese lacquer gradually came into use, consisting essentially of the same constituents as our present-day japan, usually an asphaltum base combined with oils, dryers and various oxides.

The action of this japan consists of two operations, one thermal and the other chemical. First the solvents in the combustion keep the material liquid until it has an opportunity to spread or flow evenly over the surface to be coated, whereupon it evaporates, leaving a smooth viscous covering. This is a physical process and is brought about by the application of heat and the raising of the temperature.

The material thus left after the solvent has evaporated must be changed from a viscous to an elastic solid, which change is accomplished by oxidation, the action being speeded up and given a more complete solidification by high temperatures. This constitutes the chemical process.

Some great strides have been made in shortening the time of japanning operations in the last few years. Most manufacturers who formerly allowed five to nine hours to complete their baking operations, are now doing the same work in from thirty minutes to one hour. Even better speeds are expected; in fact, at the present day, laboratory tests have produced perfectly baked japan in ten-minute periods. In this case the heat is generated electrically within the part to be japanned. This, however, is not the commercial electric japanning in which we are interested at present. In this case the oven is heated largely by energy radiated from the hot metal of the heating units and only to a slight degree by convection.

The electric heating units consist in general of a framework of steel or cast iron, supporting insulators made from mineral compounds which afford high insulation resistance even at the fusing point of the metal resistor. This resistor is usually nickel-chrome alloy, manufactured as a flat ribbon. This ribbon is wound continuously around two insulators, thus forming one heating unit. It is non-corrosive in air at 800° C., and as applied in japanning ovens, seldom reaches a temperature above 600° F. Practice has shown that it is best, where a number of these heaters are connect-

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ed, as in ovens, to use steel bus bars and to have all connections mounted upon insulators having the same characteristics as the heat insulators.

The complete heater as used in japan ovens usually runs in units of from two and one-half to 10 kilowatts each. They are small and easily movable, enabling them to be placed and replaced anywhere on the walls or floor within an oven until practically a uniform temperature is obtained throughout. This leads to high quality finish and speed together with duplication of work, both as to quality and time.

Microphotographs taken of japanned pieces where the same grade metal is covered by the same japan in the same room, one man performing all operations, show that the higher the proportion of heat by radiation and the less by convection, the higher the quality of the work. For instance, the photographs in which convection currents supply the heat show the work with large, sort of volcanic, craters unevenly distributed over the surface. These, as well as checks and cracks, not only tend to give the completed work an uneven finish, but they also impair its weathering qualities, since moisture and air can more readily reach the bare metal through these weakened spots. On the other hand, the electrically heated pieces show considerably smaller craters much more evenly distributed. By a comparison of these photographs as to coats of japan baked under similar conditions, we find that the second coat baked electrically is superior to a third coat of the other type.

Our theory as to why the electric heat gives this higher gloss and finish on the japanned pieces is purely an assumption, still both experiments and actual practice seem to bear us out.

To begin with, convection heat does not seem to have the penetrating effect of radiant heat. For example, a boiler room at a given temperature will not exhaust a man as quickly as the direct rays from the sun at the same temperature. From this it would seem that the first effect of convection heat in japanning ovens is to sear over the outer film of the japan before the inner film has hardened. The inner film of japan, or that next to the metal, then must liberate its volatile solvents, and these, forcing their way through the partly hardened outer film, evidently produce the explosive looking craters previously mentioned.

From the fewer and smaller craters of the electric baked sample it would seem the energy radiated from the electric heaters penetrates the coat of the japan so rapidly that the volatiles from that part of the japan next the metal are liberated before the outer film has set to any great extent. This probably accounts for the superiority of the electric baked product, as shown by its smooth and glossy finish.

The control of temperatures in japanning is most essential, especially where it is desired to insure uniform production of duplicate parts. Electricity can be depended upon to afford a ready, simple and dependable control. As applied to japan ovens, it takes two distinct forms. First, hand control, consisting of numerous switches so connected with the heating elements that the desired number of heaters to produce or hold a given temperature can readily be turned on or off. This is a cut and try method, but in several instances is giving very satisfactory service. The second method is the automatic control. Several types of thermostats have been tried out on this work, and it is only after considerable experimenting by different engineers that a type of instrument has been found which gives, at present, the desired results. This is a capillary tube thermometer which actuates a contactor through a relay throwing off part or all of the heaters when the oven reaches the desired temperature, and again throwing these heaters in when the temperature falls. The bulb or sensitive member of the thermometer is usually about 15 feet in length and is immersed inside the

oven. The extension of this tube outside the oven is armored and made of sufficient length to properly locate the instrument. A liquid which vaporizes at a temperature slightly above ordinary atmospheric temperature is used as the actuating fluid. The instrument as manufactured has two indicator hands which are set at the maximum and minimum points of temperature desired.

This brings us to the ovens themselves, and the methods of figuring the same from a scientific standpoint.

Prof. C. F. Hirshfeld of Cornell University, and Chief of Research Department of the Detroit Edison Co., has compiled a very complete treatise on this subject, enumerating the various heat requirements to be taken into account in japanning ovens. I will quote, at this point, from his paper. He says:

"In general the energy supplied a japanning oven may be used in the following ways:

(1) Raising the temperature of the material of which the oven is made.

(2) Raising the temperature of the air or other atmosphere originally contained in the oven.

(3) Raising the temperature of the material heated in the oven.

(4) Producing the changes which occur in the japan insofar as these changes involve the absorption of heat.

(5) Raising the temperature of ventilating or leakage air, or other material which passes through the oven.

(6) Supplying the losses from the external surfaces of the oven walls, roof and floor."

Prof. Hirshfeld has described very minutely the calculation of each of these six points. However, lack of time prohibits me from attempting to quote him further and I will say that actual practice today has worked down to a basis of constants from which the most essential heat losses are estimated, *i. e.*

(1) Losses due to radiation from the oven.

(2) Losses due to ventilation.

(3) Losses due to absorption of heat by the work together with all parts within the oven.

From the first two of these losses it is readily seen that the oven design is an important feature in all japanning. The less the radiation and ventilation losses from the oven, the greater the amount of heat available for actual work. This means, first, constructing the oven walls, roof and floor of a high-grade heat insulating material. It is also important that the material has little mass, in order to keep its heat absorption as low as possible. Up-to-date practice shows that a 4-inch to 6-inch wall lined with Diatomic earth or similar products seems to meet these requirements.

$$\text{H. Rad.} = \frac{A}{\frac{B}{C}} \qquad \begin{array}{l} A = T_2 - T_1 \\ B = \text{Thickness in inches} \\ C = \text{sp. conductivity} \end{array}$$

Furthermore, as little through metal as possible should run from the inside to the outside of the oven. The thermal conductivity value of wrought iron and mild steel, such as used for channel irons and bolts, runs about 1400 times that of a good insulating material—

(Iron—472 BTU/hr/sq. ft./°F/in.).
(Insulator .3 " " " ").

For example, a .25-inch bolt will radiate nearly the same amount of heat to the outside air as a seven-inch square of good insulating material.

Proper ventilation ($Hv = CW(T_2 - T_1)$) of japanning ovens has been greatly improved by experience. From both a baking and a safety point it has been found that just enough air must be brought into the oven to reduce the vapors given off by the japan, to below a point where it becomes an explosive mixture; but not enough air should be brought in to cool down the oven and retard the baking. It, therefore, means that each job needs a little special attention. At present it seems that the best way to handle this problem is to base the amount of ventilating area upon the amount of japan to be baked. In other words, for every gallon of japan baked within

an oven at one time there should be 1200 cu. ft. of free air taken into the oven during the vaporizing period. This leaves the fumes non-combustible and harmless. It has also been found good practice to have the ventilators distributed to different parts of the oven. The volatiles liberated from the japan being heavier than air, it is well to place some of these ventilator openings where the heavy gases will be removed first.

The heat of Absorption

$$(H_a = CW(T_2 - T_1)),$$
$$(c = \text{sp. ht. } w = \text{wt.})$$

as we all know, is easily found for different metals, etc., having given the sp. ht., the weight and the temperature change.

With the above radiation, ventilation and absorption values expressed in B.T.U's, the installation of the proper number of electric heaters to equalize these losses becomes a simple matter. For, when heat is generated electrically, its conversion is accompanied by 100 per cent efficiency; in other words, one KWH will always generate 3,412 B.T.U.

Japanning ovens, in use today, can be divided into three types; (1) the box or kiln type; (2) the semi-continuous conveyor type; (3) the continuous conveyor type.

Little need be said about the box or kiln type, as I am sure that everyone is more or less familiar with its construction. As used electrically, heaters are usually placed on the side walls or floor, being so arranged as to give the proper distribution of heat.

The second type oven, or semi-continuous conveyor, has come into quite popular use where the manufacturer does not have sufficient output of one kind to warrant carrying on the operation continuously.

There are two distinct types of this oven: The rotary oven and the box type oven with a conveyor which is moved as the operator desires.

The rotary oven is built in the form of a cylinder with a heat insulating partition through the center. With this arrangement the operator can be loading one-half of the oven while the other half is baking. This oven is very convenient where many pieces of different sizes and shapes are to be japanned.

The conveyor box type oven has doors placed at both ends, a conveyor running through the upper part from which the work is hung. This conveyor is made long enough to extend the same distance beyond each end of the oven as its length within. With this type, one charge is baking within the oven while another charge is being loaded on the receiving end. When the first japan coat is baked, the conveyor is started moving the baked pieces out of the discharging end of the oven, and the newly dipped pieces into the baking chamber the first lot has just vacated. Ovens of this type are usually built double or triple, depending on whether two or three-coat work is desired.

One of the great advantages of the semi-continuous oven over the ordinary box type oven is its conservation of heat. For example, with a baking temperature of 450 degreees Fahr. a new charge can be brought into this oven without the temperature dropping much below 300 degrees Fahr. In the ordinary box type oven the temperature necessarily must drop to a point where the operator can go within the oven to remove the baked pieces.

The third or continuous conveyor type oven is theoretically and practically much more efficient than the other types. It consists usually of a long enclosure through which the work is passed on a slow moving conveying apparatus. If desired, all handling may be eliminated by installing apparatus for loading and unloading the conveyor automatically.

The heating of this oven has been worked out very carefully, with the idea of taking as full advantage as possible of all the available heat. In most cases the electric heaters are so arranged within the different sections

of the enclosure that the incoming work is brought up to its final baking temperature by steps. Usually, in the first section of the enclosure, no heaters are installed. When this is the case, the hot baked work is brought out of the oven in such a way as to give up a good share of its stored-up heat to the cold incoming work. It is interesting to note that for the same amount of energy consumed, as high as three times the amount of work has been gotten out of the conveyor oven as out of the box type. (15 lbs. to 45 lbs. per KWH.)

Electrically heated ovens from the first have been looked upon as the solution for the prevention of fires and explosions which so often occur in japanning. I do not believe these safety features have been over-rated. I do say that care should be taken in the handling of japan as in the handling of any combustible in connection with heat. Even in electric ovens two kinds of fires are possible, although at the same time easily preventable if proper care is taken to clean the ovens thoroughly and regularly.

When pieces freshly dipped with japan are placed within an oven, there is very apt to be what is called a secondary drip when the heat is first applied. This waste japan will accumulate on the floor of the oven and bake. Each successive oven charge will add to this accumulation until a thick, porous crust of baked japan has formed, which, when heated to 500 to 600 degrees Fahr., in the presence of oxygen, will in time ignite spontaneously. If confined to the oven floor, this burning would be harmless; but if it reaches the freshly japanned work, quite a disastrous fire might result.

Again, when the volatiles given off by the japan strike a surface with a temperature lower than their own, they will condense, forming a deposit on this surface very similar to that previously described. Naturally the flues of the oven will gather most of this condensed volatile.

This deposit may cause two dangerous results: It may ignite spontaneously, back-firing into the oven, or the flues may become so clogged with this deposit that proper ventilation is cut off, leaving an explosive mixture within the oven. Ignition of any sort to this mixture might cause very serious results.

From an electrical standpoint great care has been taken to prevent ignition, even where the precautionary measures have been disregarded, as the heating units are designed with a temperature not much over 100 degress Fahr. in excess of the oven baking temperature. Except in unusual cases, this temperature will be below the flashing point of japans.

Electric japanning is a new industry, having practically grown up within the past three years. To date it comprises a connected load of around 50,000 K. W., distributed over approximately seventy-five manufacturing plants in nearly as many cities. Among its largest users are concerns like the Willys-Overland Co., which alone has a connected load of about 20,000 K. W. in heaters; the Ford Motor Co., which has adopted electric ovens for its different assembly plants over the country, and the Dodge Bros. Co., which is baking its cars almost entirely by electric heat.

In Cleveland, today, there are 18 electric ovens, between the box and semi-continuous conveyor types, in operation, while as many more are in the development stage. At present, plans are being worked out for several continuous conveyor electric ovens, and I feel perfectly safe in saying that ovens of this type will be in operation in Cleveland inside of a very few months.

The success of electric heat in japan and varnish oven work has led to considerable investigation along the line of what might be called low temperature heating, that is, temperatures up to 600 degrees Fahr. The results of these investigations have brought out numerous other applications, most prominent among which

are, electric core baking ovens, electric bread baking ovens, ovens for baking cereals, drying woolen articles, and equipments for sherardizing. The field seems unlimited. However, electric japanning and similar low temperature operations are but a few of the applications of industrial electric heat. We might classify the most important of these as follows:

First: Up to 600 degrees Fahr.—Japanning ovens and similar operations.
Second: 600 to 1200 degrees Fahr.—Drawing and tempering of the steels, annealing of the red and white metals, such as copper, brass and aluminum.
Third: 1200 to 2400 degrees Fahr.—Hardening of high-speed steels, bolt and rivet making, forging operations.
Fourth: 2400 degrees and above—Electric furnaces for the melting and refining of steel and its alloys.

From an engineering standpoint, a great deal of time can be spent in developing this infant industry of electric heating. For example, take the electric brass furnace. Several have been brought out, but none as yet are fully commercialized.

Again, in the manufacturing of steel a splendid opportunity is offered for investigation, and here we feel that in the next few years very material improvements will be made. This in spite of the fact that electric steel furnaces are competing successfully, today, in the making of steel castings and special alloy steels.

The manufacturers of electric heating devices, as well as the central stations, have long realized this immense field, and each is devoting considerable time and money experimenting along electric heating lines.

However, the industrial electric heating field is far from being confined to the efforts of the electrical engineer. It needs, in fact, the services of the entire engineering profession. For example, I will cite a problem we have before us at present, in a continuous conveyor japanning oven. The manufacturer wishes to japan 1200 thin cast iron plates per day, about 5 feet by 6 feet in size. For this work it is necessary to develop a conveyor type oven which will dip the plates in japan, give them sufficient time to drip, bake the japan, conserve the heat by having the baked hot pieces give up their heat to the cold incoming pieces, allow only enough ventilation for safety, and finally, to unload themselves when finished. All this to be done within a floor space sufficient only for loading and unloading, and with a minimum amount of labor. Thus you see the mechanical, the civil and the heating and ventilating engineer each is vitally needed in this problem.

Again, there is important work for the chemist and the metallurgist. Take the changing of japan fluid under heat and the atmosphere obtained in the oven; this must be prevented from becoming an explosive mixture. The heat treatment and metallurgy of iron, steel, aluminum and brass; the field in this work is too well known to need mention here. The development of good heat insulating materials for ovens, also the proper refractories for higher temperatures; here their work is before them and much yet remains to be done.

In conclusion, I wish to state that the applications of industrial electric heating are being developed along sound engineering lines, and thus have brought out quality, accurateness, speed and efficiency, all of which tend to a firm commercial development.

DISCUSSION

R. S. Mayer.—I would like to ask what means are used to produce the high temperature steels in these annealing and melting furnaces?

C. D. Carlson.—Use some sort of a carbon resistor.

R. S. Mayer.—Do they use the arc in any of the furnaces?

C. D. Carlson.—I don't think they use the arc in any of the annealing furnaces.

R. S. MAYER.—I mean in reducing furnaces for reducing or smelting steel.

C. D. CARLSON.—Well, in the refining and melting of steel, yes; one, two or three phases are used. The Heroult furnace is an arc furnace.

F. W. THOMAS.—Do they use the electric furnace, even in an experimental way, in burning pottery clay and the manufacture of porcelain?

C. D. CARLSON.—That has been brought out, yes. I do not know of any particular instance right now, but I have heard of it being experimented with.

MEMBER.—What comparative cost is there between the gas and the electric heater?

C. D. CARLSON.—That is an awfully big question to answer. There are so many different types and sizes that every question of that kind means a special investigation of every oven that comes up. You cannot very well give a general answer to a question like that, at least I have never been able to, nor have I found anyone else who could.

W. N. CRAFTS.—Has the electric heater been used for vitreous enameling ovens at all?

C. D. CARLSON.—They are working out a heater at present for that class of work. These heaters do not go up high enough in temperature, but there is a heater being worked out, which we hope in a short time to do that work with. That is quite a large field.

MEMBER.—Have you had any heaters applied to rubber evaporation, that is, solenoid rubber evaporation?

C. D. CARLSON.—I do not know of any. What temperature does that require?

MEMBER.—That temperature comes in about 200 or 250 degrees.

C. D. CARLSON.—I do not see any reason why it could not be done. They have been using some heaters in the rubber works at Akron. They may be using it along that line, too.

MEMBER.—In the ovens heated by gas, do they heat the articles before they put the japan on, or the same as they do when it is heated by electricity?

C. D. CARLSON.—No, they do not do that in either case. The Japan is applied while it is cold, and then the work inserted right in the oven. That is, in the case of a continuous or semi-continuous oven the work goes right into the hot oven, but on an ordinary box oven, where the temperature is brought up from room temperature, in that case, of course, it goes into the cold oven. The only case of the work being heated is one experiment where the heat is generated electrically within the piece. In that case the piece is heated and sort of bakes itself.

W. N. CRAFTS.—How do the results in the use of that method compare? I understood you to say it was not commercial yet; but do you get better results?

C. D. CARLSON.—The results in that method are very good; but as I say there are so many things to take into account, such as the size of pieces etc., that it has not really been worked out commercially.

W. N. CRAFTS.—I think it would be very hard to get a uniform temperature.

C. D. CARLSON.—That is the big difficulty at the present time, but I have seen some very good pieces japanned that way.

W. N. CRAFTS.—It would seem as though that method would do away with the little volcanic craters that you spoke of.

C. D. CARLSON.—It does. That is just the point. It bakes from the inside out, and drives all the fumes off before any craters form.

MEMBER.—Is the natural draft sufficient for ventilating, or is it ever required?

C. D. CARLSON.—In most cases they are putting in a little forced ventilation. That keeps about the same temperature and the same moisture in the oven, independent of the outside air. It makes no difference whether it is a rainy day or a sunny day. It gives

better duplicate work, and also where there is a long row of ovens, the natural draft would not take off the fumes fast enough.

Member.—How often do you count on changing the air in the oven?

C. D. Carlson.—Well, it takes anywhere from twenty to thirty changes per hour. We usually figure it from the amount of japan baked within the hour. It works out better that way than it does to make any standard number of changes per hour, because one of them might not use as much japan as the other.

Member.—What is the character of gas and how do you dispose of it? I mean the gas that is given off of the work?

C. D. Carlson.—That is what we take care of by having enough ventilation to prevent there being an explosive mixture. It is a volatile gas, quite heavy, and the best way to take care of it is to have part of your ventilators near the floor. In that way those gases will be swept out before they come up into the japan work, and it will give you better results.

Member.—You turn them into the atmosphere, do you?

C. D. Carlson.—Yes, they usually go out through a stack.

F. D. Davis.—What is the large saving in electric japanning, time?

C. D. Carlson.—Time and your improved work. The electric oven, in fact, has revolutionized the whole japanning field.

W. N. Crafts.—What is the life of these heaters?

C. D. Carlson.—Well, as far as we know, they may be indefinite. The ones that were first started, about three years or more ago, are still running. They do not get up high enough temperature. In fact, you look inside of an oven with these heaters on and you would never know there was any heat in there from the heaters themselves. When they were first brought out, they did get to a dull red heat, but it was afterwards found much better to bring that temperature down under the flashing point of japan; so I might say the life is practically indefinite. They are tested out to 800 degrees C., and usually run about 600 degrees F.

Ed. Lindmueller.—What is the effect on the colored enamel? Does it give a clear color?

C. D. Carlson.—Yes, because you have no fumes or combustibles inside of the oven to close up your baking. I have seen some good color work, and good white work, which is very hard to produce in duplicate.

C. C. Smith.—What is the flashing point of japan?

C. D. Carlson.—It varies, but usually about 650 degrees F. Some may go a little above that, and some a little below. It all depends upon the proportion of your naphtha, or whatever you have in there, which sets it off.

Member.—How long do the heaters last? Referring to the metal heaters.

C. D. Carlson.—I do not know how long they will last. They have only been running for about three years and the first ones are still being used.

Member.—How is the efficiency of the heaters? Does the efficiency increase with the time they are in use?

C. D. Carlson.—No, it should not. They are not brought up to a high enough temperature to affect them in that way at all.

Member.—Referring to the amount of work per kilowatt hour they will do, is there any data on that?

C. D. Carlson.—We have found in some of the conveyor-type ovens that they are getting out as high as fifty pounds per kilowatt hour, which will be in proportion to some box-type ovens down to fifteen pounds.

H. C. Gillie.—In the industrial heating field, the relatively low temperature electric japanning is the simplest problem and it is up to the engineers to work out the higher temperature fields.

I am particularly interested in electric heat for forging work; some

rather elaborate experiments have been carried out in heating iron and steel for forging purposes by passing the current directly through the piece to be heated. This has worked out successfully for heating the ends of pieces of uniform cross section, such as is desired for upsetting, bolt heading and work of this nature. A bolt heading electric heating machine has been developed by one of the large electrical manufacturers, which heats the stock and passes it automatically to the bolt heading machine. A rivet heater has also been developed.

The brass melting field should be given attention at this time by engineers. Anyone in the brass factories knows the difficulty of securing crucibles of good quality. A properly designed electric brass furnace, with its temperature control, its reducing atmosphere and not too expensive, will be a great step for the brass industry. The electrical manufacturers and several of the central stations are developing some ideas at the present time and we hope a good furnace will soon be on the market.

I want to emphasize the broadness of the engineering work involved. The electrical can be well taken care of; the chemical, metallurgical and mechanical are needed.

W. N. CRAFTS.—I think that the subject this evening is merely the beginning of what we are going to hear more and more of in the next few years. Electric heating is in its infancy, and I think more and more your programs in the coming years will have detailed information about various branches of the industry. Several different lines have been referred to tonight. I was interested in what Mr. Carlson said to the effect that japanning is one of the simpler problems, and what Mr. Gillie said, that the electrical part of the development is simple. Electricity is so well known and so well handled now that it is a case of solving other problems in other departments of engineering on account of the enormous power and heat there is in electricity. I have been up against the refractory question. In electric steel melting furnaces enormous temperatures can be obtained. I have seen temperatures in electric furnaces up around 3500 or 3600 degrees Fahrenheit; in fact, I have seen magnesite fused. That is one of the difficulties we are facing, to hold the heat which electricity can produce within the limits that we want.

Handling Materials Automatically With Skip Hoists.

By H. V. Schiefer*

Paper presented April 21, 1917.

Index No. 621.86 ..

The skip hoist has long found favor as a machine for handling granular materials. The introduction of the automatic slow down and discharge gave it a permanent place among material-handling machines. Now we have a skip hoist that is entirely automatic in its functions. In other words, we can place a railroad car of material over a track hopper, open the gates of the car and in a short time return and find a large quantity of material automatically transferred to an overhead bin without even the services of an attendant; in fact, the doors of the hoisting engine house are usually kept locked excepting when the plant electrician or oiler inspects the equipment, say once a day.

A skip hoist may be described as a bucket (usually called a skip) that travels up and down a runway by means of a cable wound over a drum of a hoisting engine. From the nature of the machine the only parts subject to wear are the wheels of the skip bucket, the cable and the hoisting engine itself. The wheels are made of chilled cast iron or steel and of such size as to reduce the wear to a minimum. The hoisting engine gears run in oil-tight gear cases, thereby reducing wear. The hoisting ropes

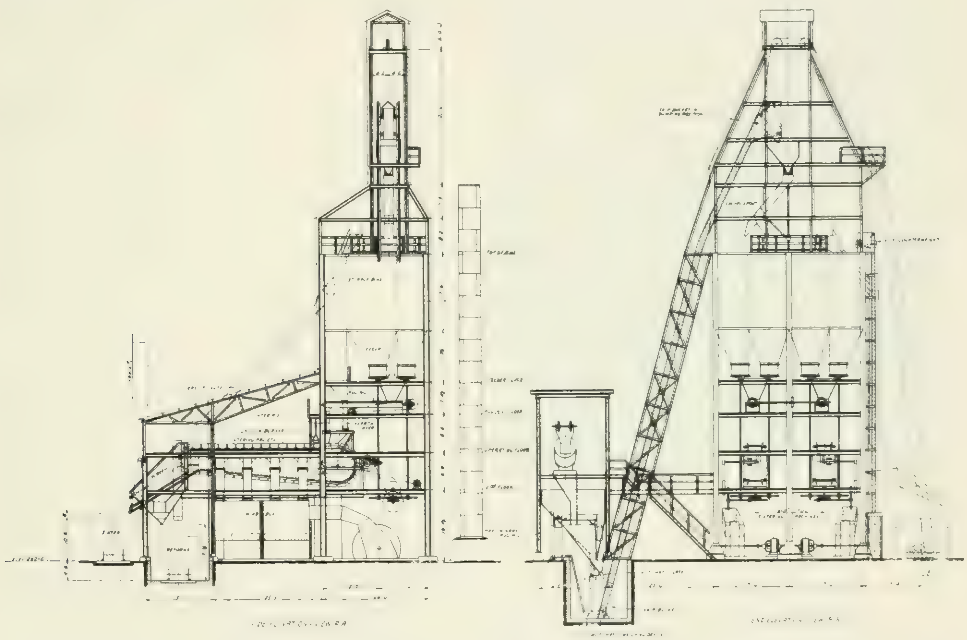


Fig. 1—Drawing of Flue Dust Sintering Plant in Which a Skip Hoist Influenced the Design

*Engineer The C. O. Bartlett & Snow Co., Cleveland, O.

will last a long time and when they need renewing they can be replaced quickly at a moderate cost.

In the past a bucket elevator or an inclined conveyor has been used to elevate materials in bulk. The limitations of an inclined conveyor are such that it cannot be inclined more than the natural angle of repose of the material handled without the intro-

FIG. 2—PHOTOGRAPH OF FLUE DUST SINTERING PLANT THAT IS SHOWN IN OUTLINE IN FIG. 1

duction of flights or buckets, in which case the conveyor becomes an inclined elevator. Thus to elevate materials to say 100 feet with a conveyor, a considerable amount of ground space is required and also a very expensive belt or chain. Both of these are serious objections to the average plant manager, the first being that where a conveyor is installed the ground is usually valuable and cluttered up with other machinery, buildings, tracks, etc. The objection to a chain or belt is, of course, the high maintenance charge.

When comparing an elevator with a skip hoist I do not wish to convey the idea that all elevators should be replaced with skip hoists. The elevator and the conveyor have their places and the skip hoist has its adaptations. For small capacities and medium lifts the skip hoist cannot compete with the elevator; neither can it compete for large capacities with medium lifts, say 75 feet, with easy flowing non-abrasive materials such as grain.

The field for the skip hoist is broad. It has not been thoroughly developed, but with the introduction of the automatic features it is getting immediate recognition and favor. In mines, quarries and rock-crushing plants the advantages can be readily seen. Large sums of money have been expended in trying to hoist coal from mines with bucket elevators instead of the usual method of hoisting the mine cars to the surface by means of a hoisting engine operated by a high priced engineer, necessitating expensive safety devices, cage loaders, etc. The automatic skip hoist lends itself admirably to such a case. The mine cars could be dumped at the bottom of the mine directly to the automatic skip which would take care of the hoisting automatically. The height to which a skip hoist can elevate material runs into thousands of feet and it is this feature that makes a skip hoist successful in handling coal from a mine where an elevator would fail. The maximum height to which an average elevator can be used economically is something under 100 feet.

In quarries, rock crushing plants, sand and gravel plants, etc., skip hoists are used to advantage, the points of advantage being that the material is carried in a bucket and does not come in contact with moving parts of the equipment. In handling gritty or abrasive materials this point is the one that makes the skip hoist desirable.

The greatest use of the automatic skip hoist at the present time is the

handling of boiler house coal, coke, ashes, in steel mills; limestone, flue dust, slag, in power houses, etc. It lends itself to almost any condition and can be installed at any angle from about 15 degrees up to 90 degrees to the horizontal.

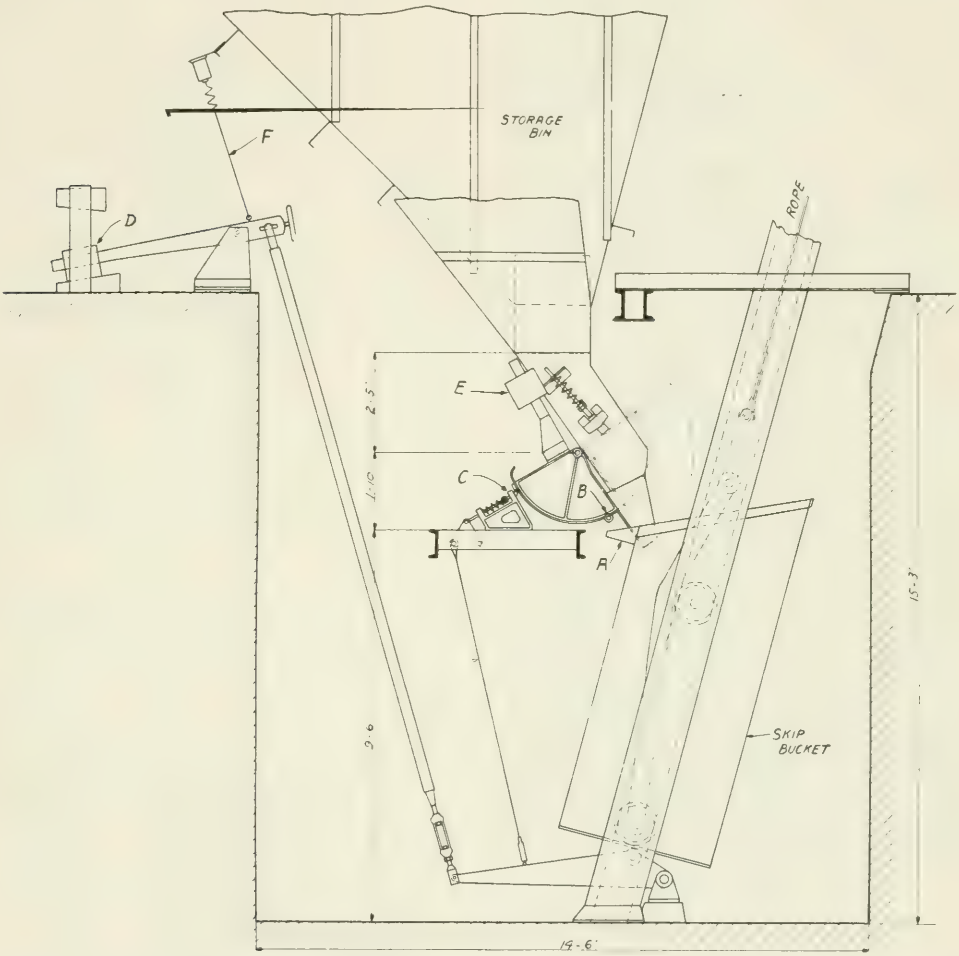


FIG. 3—DRAWING OF SKIP HOIST PIT SHOWING SYSTEM OF AUTOMATIC LEVERS IN SINTERING PLANT

The skip hoist does not operate continuously, but only when material is fed to it. This is a point of advantage if one must compare the skip hoist with an elevator or conveyor. There are very few instances in which materials are handled continuously, there being times when an elevator or conveyor would run empty if an operator did not shut them off. Not so with an automatic skip hoist.

When considering the workman's protection the automatic skip hoist offers the last word in safety first, since there are no operators, therefore no accidents to workmen. In other words, it is fool-proof. The most serious accident that can happen to a skip hoist is the parting of a cable or the slipping of a brake on the motor, both of which are rare

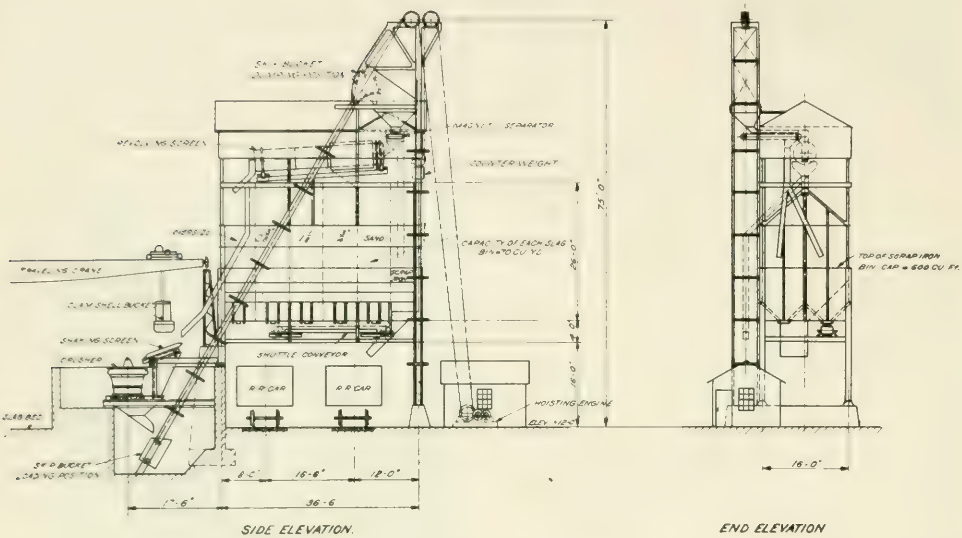


FIG. 4—DRAWING OF SLAG CRUSHING PLANT IN WHICH A SKIP HOIST WAS SUCCESSFULLY UTILIZED

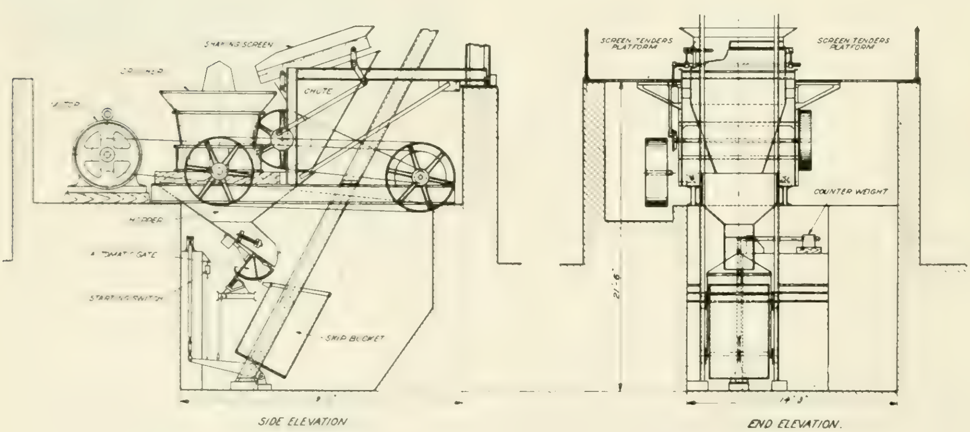


FIG. 5—ARRANGEMENT OF SKIP HOIST PIT SHOWN IN FIG. 4

occurrences and the result is simply a dented bucket bottom.

General Construction

There are three general types of skip hoist construction, as follows:

(1) One skip bucket with counterweight.

(2) One skip bucket without counterweight.

(3) Two skip buckets in balance.

Practically all skip hoists are included in the above types. Any one of these types allows for the application of entire automatic or semiautomatic control. When we speak of an entirely automatic skip hoist we imply one that performs all of its functions without human assistance, one that loads, starts, hoists and discharges entirely by means of an electrical controlling device. A semiautomatic skip hoist is one that hoists, discharges and returns, or that hoists and discharges automatically but does not load or start automatically.

Entire Automatic Control

An entirely automatic skip hoist requires that there be a storage hopper from which the material is delivered to the skip buckets. This storage hopper need not be large. If for example the skip hoist is being fed by a conveyor the storage hopper need be only large enough to hold material from the conveyor until the skip bucket has made a round trip. This may not even be equal to the capacity of the skip bucket. There is no limit as to the other extreme in size. The entire automatic control is most frequently used where the material is of a free, flowing nature and also where it is required to hoist a regular quantity to a given height. It is impossible to get a real automatic control handling a material that is sticky. It is absolutely necessary that the material flow easily and quickly through a gate of nominal size. This type of hoist is particularly adapted to such materials as coal, sand, gravel, crushed stone, crushed slag, fine ore, etc., in short any free-flowing material in which the lumps do not run much over six or eight inches in size for ordinary capacities, say 200 tons per hour maximum. With larger capacities larger lumps can be handled.

The receiving or storage hopper is usually made of steel and when using two skip buckets in balance it requires to be double, each half being fitted with a chute provided with a gate and arranged to deliver into the skip buckets. The gates are so designed that they will automatically be closed except when the skip bucket is in position to receive material. If enough material is contained in the storage hopper to fill the skip bucket, it automatically starts and continues operating until there is not enough material left in the hopper to fill

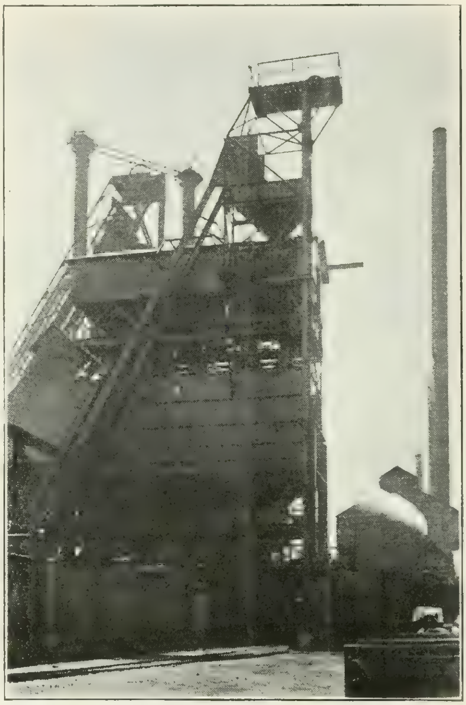


Fig. 6—Slag Crushing and Classifying Plant in Which All Material is Elevated With Full Automatic Counterbalanced Skip Hoist

Detail of skip hoist pit is shown in Fig. 5. A blast furnace skip hoist runway is shown in the background.

Cleveland Furnace Co., Cleveland.

the skip bucket, in which case it automatically stops.

To fully describe the entire automatic system, let us assume first of all that ore is to be elevated from location for dumping. The bucket which is in the lower position will have opened on its downward travel the gate of the chute from the track hopper, thus permitting a flow of

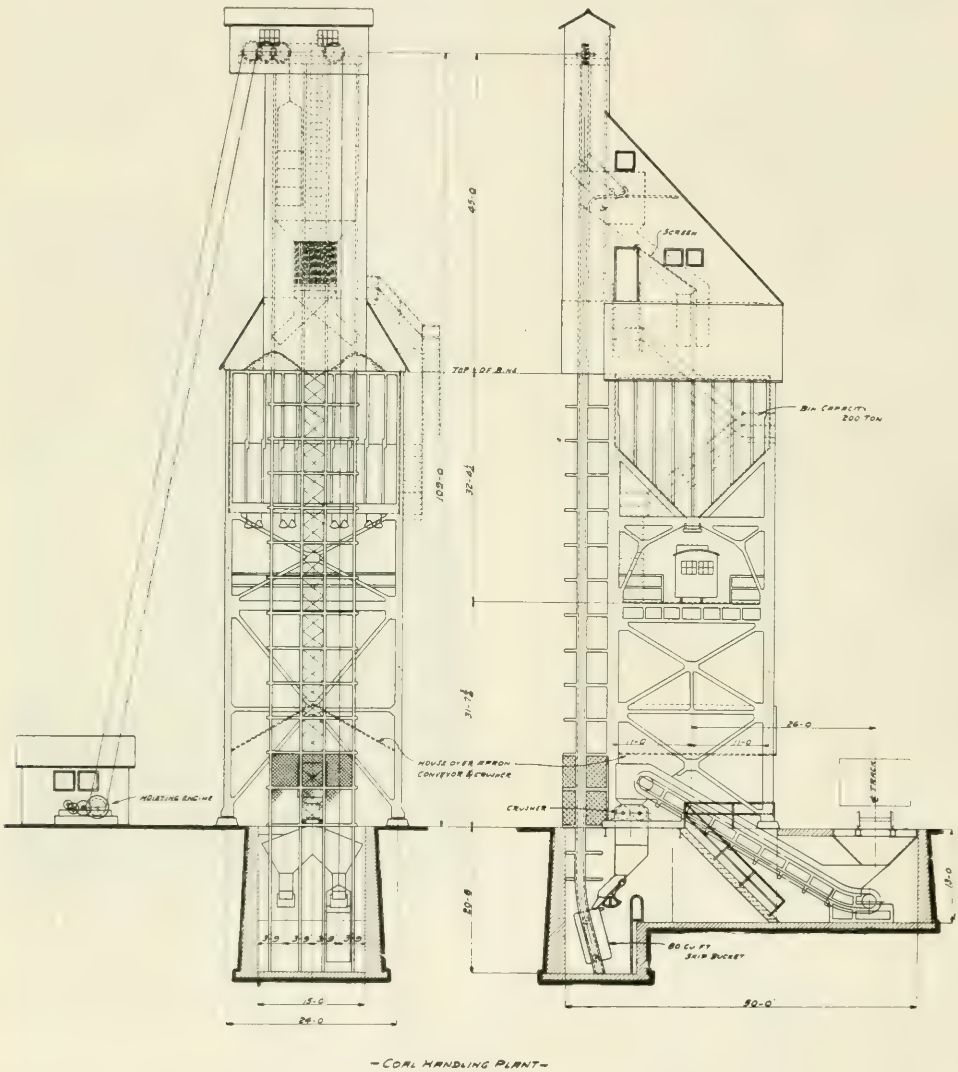


FIG. 7—COAL HANDLING EQUIPMENT FOR HANDLING COAL FROM RAILROAD CARS TO OVERHEAD STORAGE BINS

a track hopper by means of skip buckets to an overhead bin. Assume an empty bucket at the bottom under one of the track hopper gates, the companion bucket having been hoisted to the top position in the proper ore from the track hopper into the skip bucket. As soon as the bucket is sufficiently loaded, its weight raises the counterweight, which automatically closes the gate of the chute leading from the track hopper, thus stopping

the flow of ore into the skip bucket. In addition to closing the gate it also operates an electric switch, which admits current to the hoisting engine motor. The skip bucket then starts upward slowly and after a short period of time, by means of the automatic control system, the motor is accelerated and the bucket travels at full speed until it nears the top or dumping position, at which point the slow-down resistance is inserted

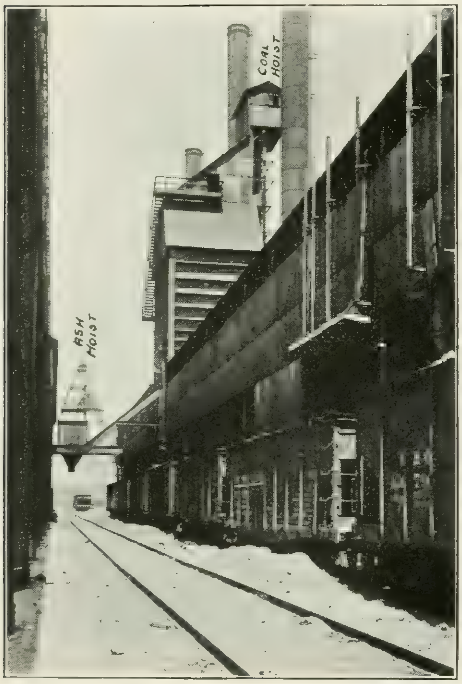


FIG. 8—FULL AUTOMATIC COAL HOIST AND SEMI-AUTOMATIC ASH HOIST HANDLING MATERIALS TO AND FROM A ROW OF GAS PRODUCERS

Showing the small amount of ground space required.

and at the proper moment the power is cut off from the motor and the solenoid brake applied, thus bringing the bucket to a stop in the dumping position, the other bucket being in the lower or initial position ready to repeat the cycle of operation.

Fig. 1 shows a sectional view of a flue dust sintering plant in which a full automatic skip hoist was the deciding factor in the design of the plant. There are ten overhead bins in which five different kinds of materials are to be stored. One skip hoist is used in connection with a

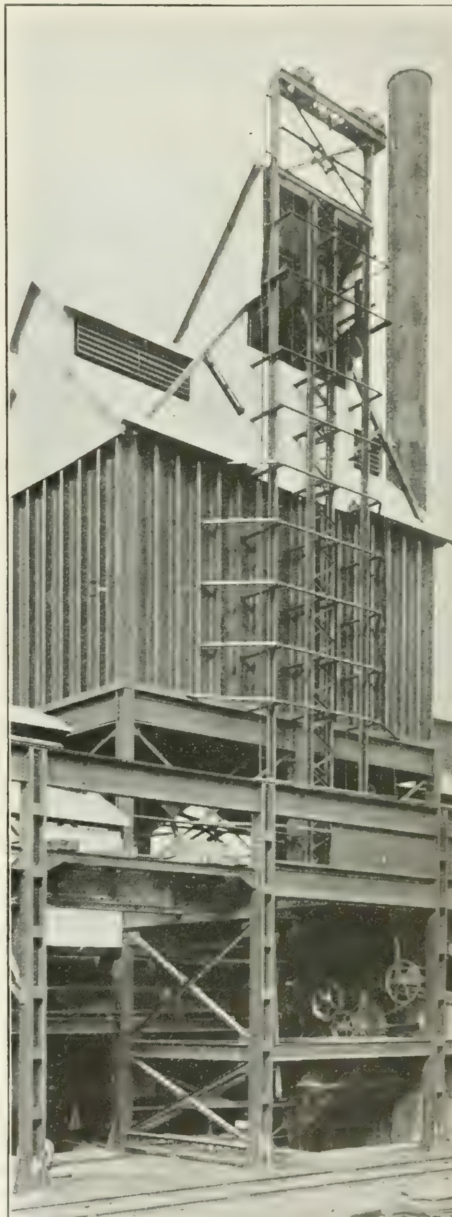


FIG. 9—DOUBLE FULL AUTOMATIC SKIP HOIST HANDLING COAL FROM TRACK HOPPER TO OVERHEAD STORAGE BINS

Used in connection with steel mill soaking pits

long swivel spout that is manipulated by hand so that it discharges into the proper spout. This is a single bucket skip hoist which is run in conjunction with a counterweight. The rope that holds the bucket is threaded up over the house and down placed in such manner that the skip bucket rests on the short end of the arm and the weight of the empty skip bucket is insufficient to raise the counterweight. The bucket is provided with a pair of lugs (A), one on either side of the bucket. As the

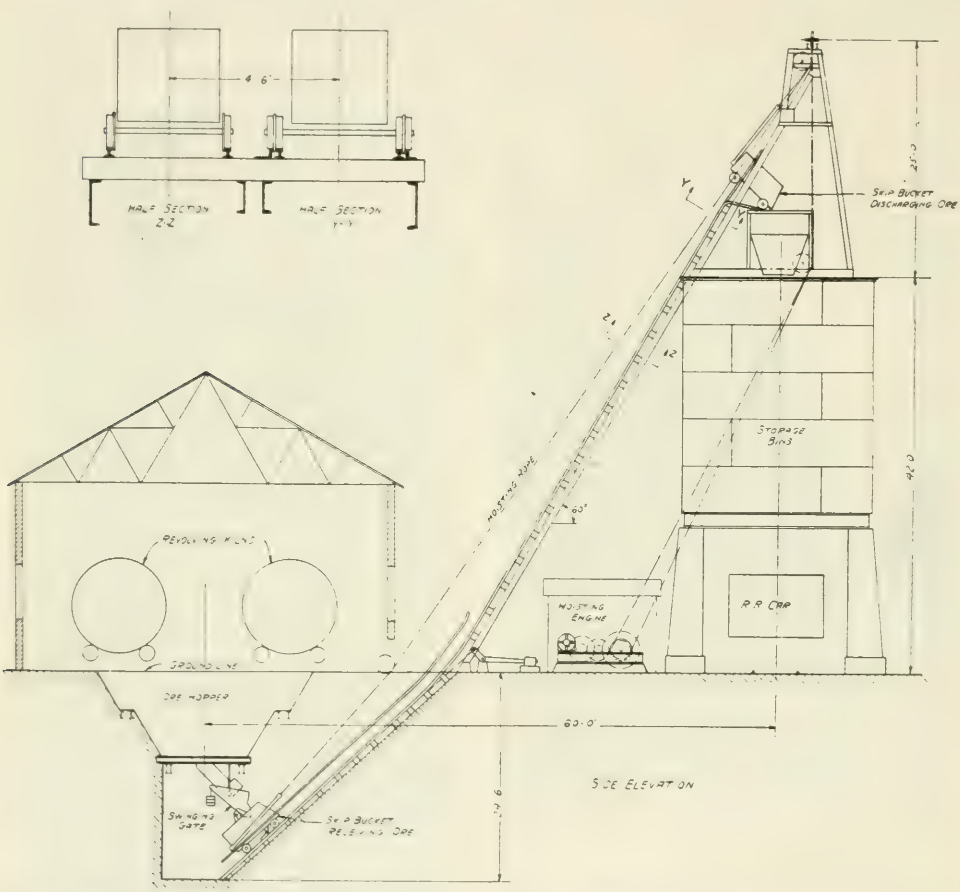


FIG. 10—PLANT FOR HANDLING HOT NODULIZED ORE FROM KILNS TO OVERHEAD STORAGE BINS

the opposite side to the hoisting engine drum. Another rope leaves the drum from the opposite side and leads up over a sheave to the counterweight. The hoisting engine house and counterweight show prominently in Fig. 2, which is an exterior photograph of the plant that is shown in outline in Fig. 1.

Fig. 3 shows a mechanical control system consisting of a set of counterweighted levers in the skip hoist pit, bucket descends it is slowed up by the electrical control. It is not until the bucket has slowed almost to a stop that the lugs on the bucket strike a pair of rollers (B) that are attached to an undercut, quadrant gate. This gate is pulled open until the latch (C) is engaged and prevents closing until the latch is released. The bucket then sinks on for a few inches farther coming to a rest on the counterweighted levers. Material in the mean-

time has started to flow into the bucket and continues to do so until the weight of the material is such that the counterweight (*D*) rises. The counterweight in rising pulls open the latch (*C*) which has all the while held the gate open. The gate immediately closes being actuated by counterweights (*E*). The counterweight (*D*) when rising pulls the rope (*F*) which is connected to a starting switch which admits current to the hoisting engine motor and the bucket starts on its upward journey.

Should the electric power be cut off the gate would close, the bucket would stay at the bottom and no material would spill into the pit. In some of the earlier types of automatic skip hoists the latch was not employed, the gate being held open by the lug on the bucket. With the power cut off, gate open and no attendant, the hopper emptied itself in the pit. This cannot occur with the device as shown in the illustration.

In some cases it is desirable to hoist more than one kind of material at different times with the same skip hoist. When materials with widely varying specific gravities, such as coke and ore, are to be hoisted, it is either a case of a full bucket of coke and a very small amount of ore, or it is necessary to shift the heavy counterweight. To overcome this difficulty a lever is employed with an adjustable lever arm. This adjustment can be made easily and quickly by the employment of a hand wheel mounted on a screw provided with a nut onto which is fastened the connecting rod.

Fig. 4 exemplifies a modern plant for the crushing and classifying of blast furnace slag in which an automatic skip hoist receives crushed slag directly from a crusher and elevates it about 70 feet to a revolving screen. Slag is a very abrasive material but can be handled with a minimum amount of wear to equipment by means of a skip hoist. The shallowness of the skip pit is shown in Fig. 5. The depth of the pit is very little, if any, deeper than would be required for an elevator or conveyor to do the same work. A photograph of this installation which is at the plant of The Cleveland Furnace Co. is shown in Fig. 6. A blast furnace skip hoist shows very prominently in the background.

The double full automatic skip hoist has been used extensively for elevating coal for gas producers, power houses, etc., where there is a large capacity

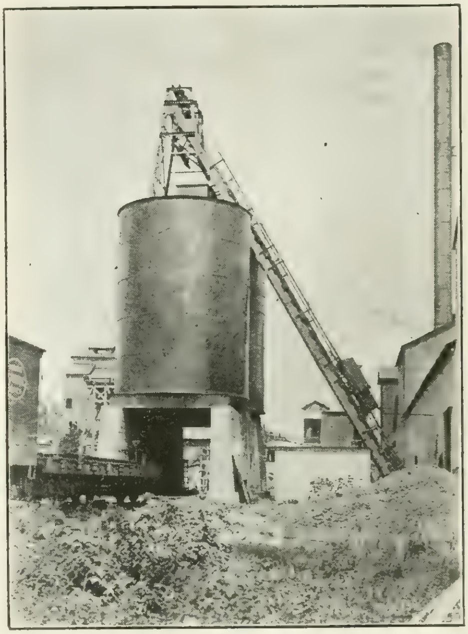


Fig. 11—Ore Handling Skip Hoist as Shown in Fig. 10

The Benson Mines Co., Benson Mines, N. Y.

required and a lift of 100 feet or more. Fig. 7 shows in diagram a plant in which run-of-mine coal is received in railroad cars. It is then dropped into a track hopper under which is placed a feeding conveyor that feeds the coal to a two-roll crusher. From the crusher the coal is fed into an automatic skip hoist which elevates the coal to the overhead storage bins. Fig. 8 shows an installation of this character at the plant of the Corrigan-McKinney Co., Cleveland, in which the lift is about 100 feet. Two 3-ton buckets are used

and they elevate coal at the rate of 175 tons per hour.

Fig. 9 illustrates the first full automatic skip hoist ever built, in which coal is received from a railroad car on an elevated trestle and fed to the skip hoist by a double plunger feeder.

Figs. 10 and 11 illustrate a double entirely automatic skip hoist that is handling hot nodulized ore from kilns to storage bins, operating under the most adverse conditions conceivable. Red hot nodulized ore is discharged from two revolving kilns into a storage hopper provided with two gates in the bottom. When drawing red hot material from the hopper a stream of water is sprayed on it which causes the pit under the hopper to be full of steam and hot water. Any type of conveyor or elevator was out of the question, therefore a skip hoist that is entirely automatic requiring no inspection whatever was installed in the pit. The material handled being of an extremely abrasive character a gate of rugged design was adopted. It is entirely of cast iron with a double shell enclosing an air space to assist in cooling.

White iron removable linings are provided to take care of excessive wear. For controlling the flow of material a semicircular cut-off gate of cast iron is provided operated by a bell crank and connection to the skip hoist bucket. The construction of this gate and the detailed construction of the mechanical part of the automatic mechanism in the pit of this skip hoist are shown in Fig. 12. In some instances it is an advantage to have levers, counterweights, etc., out of the skip pit. In this case it was a necessity owing to the steaming condition of the pit. Fig. 13 shows a view looking up the runway of this skip hoist.

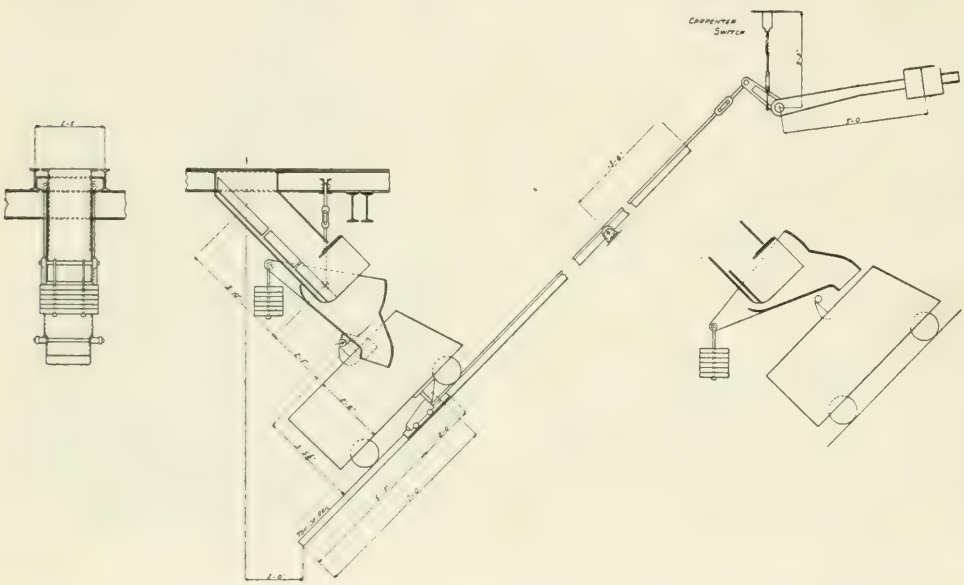


FIG. 12.—DETAIL OF AUTOMATIC LOADING APPARATUS SHOWN IN FIG. 10

When used entirely automatically the skip buckets are seldom made of a less capacity than two tons each. They are rectangular in shape of steel plates ¼-inch to ½-inch with flat bottoms to rest on a counterweighted lever. When handling abrasive materials a renewable lining of steel plates is usually added. Two axles are used on which are mounted chilled cast iron or steel rollers that run in the guides of the skip runway.

The dumping of the bucket is accomplished entirely by the arrangement of the guides on which the skip rollers run. There are two general types of dumping guides: 1st—that type in which all four of the skip rollers are alike; 2nd, that type in which one set of skip rollers has a wider flange than the other set. The first type depends entirely on gravity and the arrangement of the guides to properly discharge the bucket. For the second type two sets of rails are provided at the top of the runway, one pair for the front wheels of the skip bucket and the other pair of wider gauge for engaging a special tread on the rear wheels.

Fig. 14 shows a typical hoisting engine consisting of a heavy structural steel base on which is mounted a cast iron drum connected through a train of spur gears to an electric motor. The electric motor so admirably adapts itself to this type of mechanism that a steam engine has never been used in connection with an entirely automatic skip hoist.

The rope speed is seldom over 200 feet per minute which means a slow speed drum shaft, consequently several sets of gears to get the proper speed from a motor running on an average about 850 revolutions per minute. The frame for mounting these various gear reductions, motor, etc., has passed through the experimental stage and is now made entirely of structural steel shapes properly stiffened and riveted. With this type of frame there is not the possibility of cracking that there was in the older type of cast iron frames. To reduce friction and consequent wear to a minimum, all gears are cut and run in cast iron oil-tight gear cases. A solenoid brake, usually placed on an extension to the motor armature shaft, is used on all engines of this type. The motor is fastened to this shaft extension by means of a flanged coupling, thus permitting the motor to be dismounted and replaced without disturbing the brake or any gears.

The success of the automatic skip hoist depends entirely on the electrical control. The mechanical control is a device for filling the skip bucket and starting the motor only. The major part of the operations of the equipment being performed by the electrical control, viz., accelerating the motor, decelerating, pausing, reversing, etc. The automatic electrical control consists of a plain slate panel supported on a steel frame usually placed near the hoisting engine (see Fig. 15). On this panel are mounted the solenoid operated primary reversing switches, also the various solenoid operated accelerating switches with their current relays. In the case of alternating current it is interesting to note that the primary reversing switch opens but two of the three phases, this being all that is necessary to reverse the motor. The third

Fig. 13—Inclined Skip Hoist for Handling Hot Ore From Kilns to Storage Hoppers
Looking up the inclined runway.

phase remains permanently connected to the line.

The accelerating switches automatically cut resistance out of the rotor circuit under control of current relays. The solenoid switches are so designed as to cut one step of resistance out of three phases of the rotor circuit simultaneously, thereby maintaining a proper electrical balance at all times.

The electrical control performs its functions through the use of a specially designed limit switch which is geared directly to the hoisting engine drum shaft through a set of bevel gears. This limit switch consists of a cast iron case in which is mounted a long screw. On this screw is a traveling nut which moves back and forth as the motor is reversed, operating at the predetermined points, sets of contacts, eight in all, four at each end of the limit switch. Fig. 16 illustrates this switch.

At any time that the power is shut off the hoist either by the control or by accident, a solenoid operated brake is automatically applied. The brake is freed by the raising of a counterweight by an energized solenoid. When power is cut off from the solenoid the weight drops, setting the brake.

The semi-automatic control system or as it is sometimes called, the push-button control system, operates much the same as the full automatic type. It is used only where intermittent service is required or where the material is of such size and nature as to require special consideration at the loading point, and also where it is not convenient to have a storage hopper such as is required by the full automatic type. In order to understand the action of the semi-automatic type, let us consider that ore is to be handled intermittently. Assume the empty skip bucket at the bottom of the skip runway. This is filled with ore from a small car or chute. The starting button is then pushed, whereupon the bucket starts upward

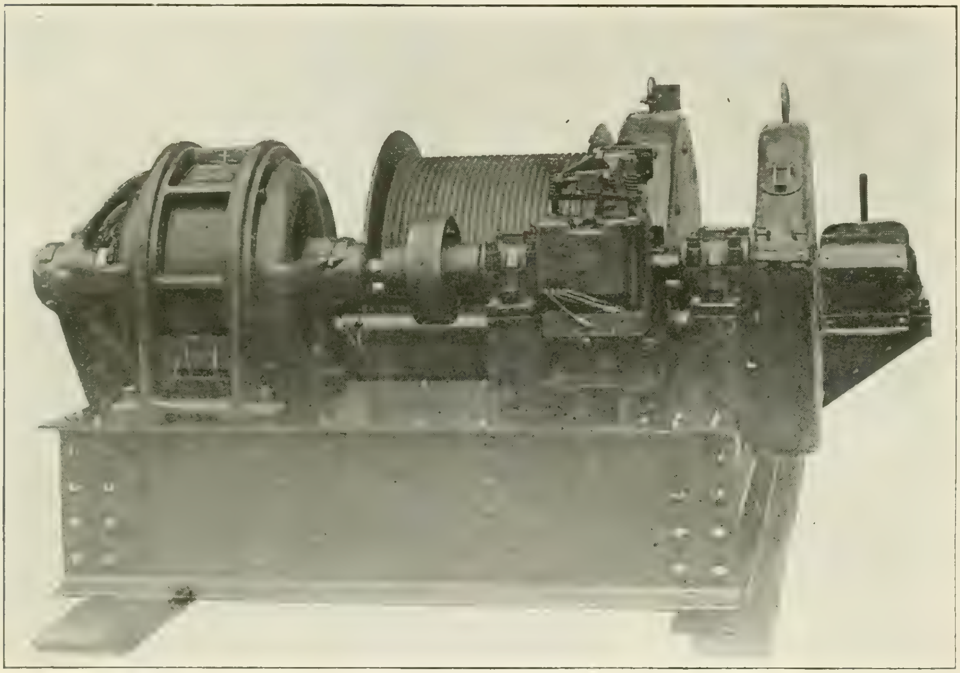


FIG. 14—ELECTRIC HOISTING ENGINE

slowly and after a short period of time the motor is accelerated, the bucket traveling at full speed until it reaches the upper position at which point the slow-down resistance is inserted and the bucket brought to a stop in the dumping position, where it remains for a period of several seconds to insure the perfect discharge of the material from the bucket. It is then by means of a time relay switch

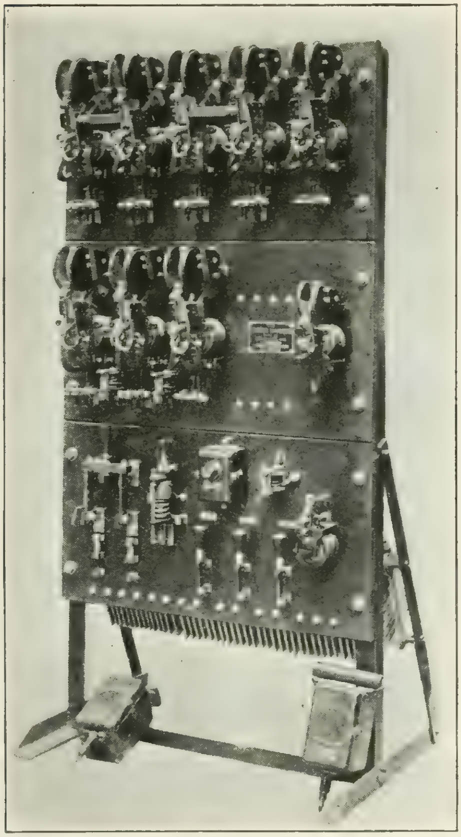


FIG. 15—TWO BUCKET FULL-AUTOMATIC SKIP HOIST CONTROLLER

in the control system returned to the bottom or initial position, where it comes to rest and must so remain until the operator repeats the cycle of operation by pushing the starting button. Or as in the case when two buckets are used in counterbalance the pushing of the button starts the same cycle described above except

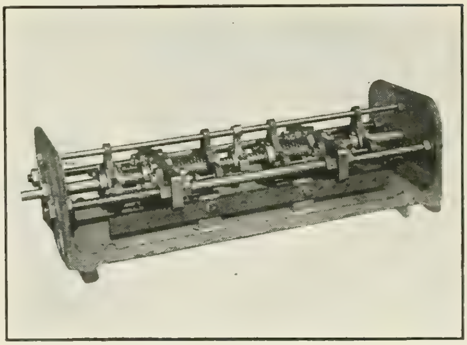


FIG. 16—STANDARD TYPE OF LIMIT SWITCH

This switch is geared to the hoisting engine drum shaft.

that the cycle ends with the stopping of the bucket in the dumping position, there not being required any time relay switch.

Blast furnace skip hoists constitute a large percentage of installations of this type, i. e., push button. More than 100,000,000 tons of ore are hoisted into blast furnaces annually; practically all of which is handled by semi-automatic skip hoists. Fig. 17 shows a typical blast furnace skip hoist.

Probably the next largest class of semi-automatic skip hoists are those used for elevating ashes into a bin or car. The usual condition is shown in Fig. 18, in which a load of ashes

FIG. 17—BLAST FURNACE SKIP HOIST

This type handles over 100,000,000 tons of material annually.

Courtesy of Arthur G. McKee & Co. Cleveland.

is collected and brought to the hoist in a small car holding one skip bucket load. The man who collects the ashes is a very low priced man and all he has to do is to dump his load of ashes into the skip hoist, press the starting button and go on about his

DISCUSSION

ED. LINDERS.—How sensitive are the automatic outfits relative to weight? Is it within 1 per cent., 5 per cent, or 10 per cent in their operating?

H. V. SCHIEFER.—The answer to

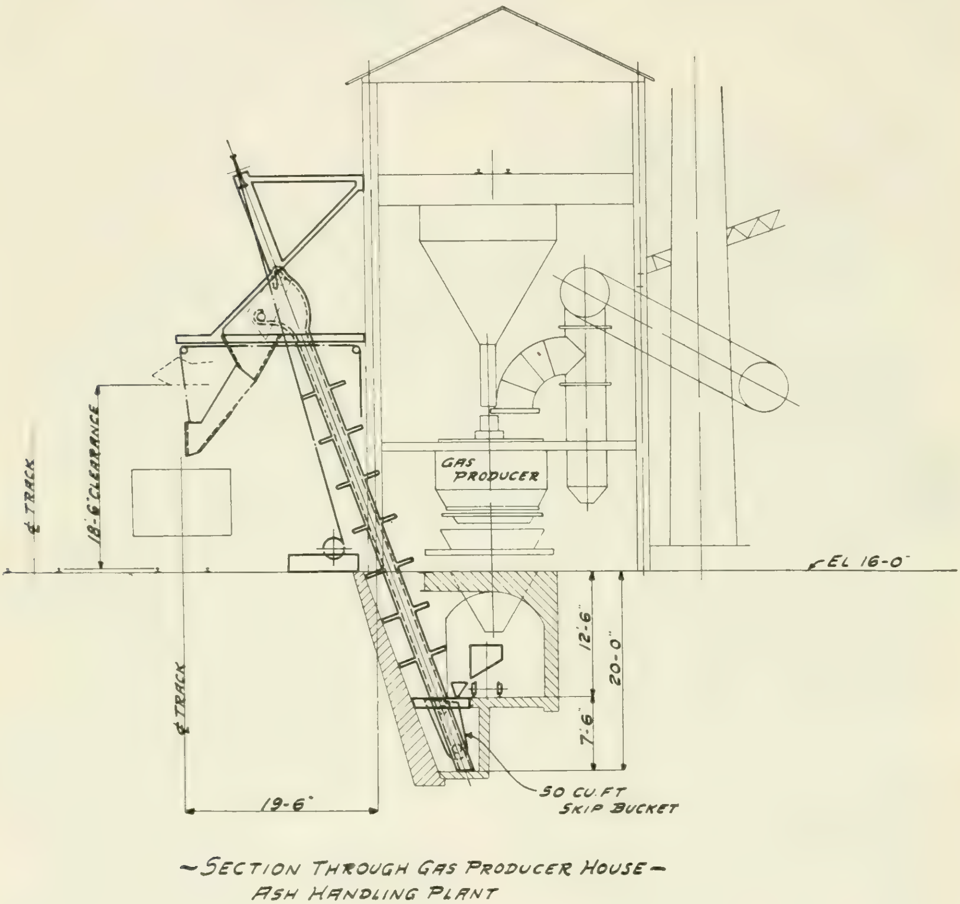


FIG. 18—ASH HOIST FOR ELEVATING ASHES FROM GAS PRODUCERS TO RAILROAD CARS

business. The hoist automatically elevates the bucket, dumps the ashes and the empty bucket returns to the loading position.

Fig. 19 shows an ash hoist that elevates ashes from a row of gas producers and deposits them into a bin that is located directly over a railroad track.

that, I believe, can be seen by observing a number of curves taken with a recording ammeter. The curves are so nearly alike that if we get them shuffled up we cannot tell them apart. Just exactly how sensitive I could not say, but I would say at a guess, a remote guess, it would be very much closer than 5 per cent, as close I

believe as any recording weighing device on the market. It has always been our practice to make the pins in the levers large enough so that if the bucket drops it will not break the pin, but will dent the bucket, consequently with large pins in the levers you do not get very extraordinarly accurate weighing.

Ed. Linders.—How do they take care of the stretch of ropes on the automatic outfits?

H. V. Schiefer.—In the case of a semi-automatic skip the bucket never rests on the ground; consequently the load is always on the rope, and since the loading position of the bucket can vary several inches, a few inches of stretch does not affect the operation.

In the case of the entirely automatic skip the buckets rest on a counterweighted lever at the bottom causing a slack rope. When the rope stretches the slack rope sags a little more until the whip of the rope is quite noticeable. This acts as an alarm and then the operator knows that a few inches of rope must come out.

After a few days practically all of the stretch will be taken out and there is very little time lost on that account thereafter.

Ed. Linders.—What method is used in shifting the fulcrum point when handling coal, coke and ore in the same shift?

H. V. Schiefer.—The fulcrum point is shifted by means of a screw and nut in conjunction with a hand wheel. This arrangement works best when using two different weights in the bucket so that the nut may be jammed at either end of its travel thus automatically locking it in place.

Ed. Linders.—It takes coarse materials?

H. V. Schiefer.—It takes care of a number of different materials, but we figure that with a full bucket of coke we can use a partial bucket of something else.

A Member.—In Pennsylvania there was a mine which had quite a lot of water in the bottom, and one of the engineering concerns in Cleveland installed an automatic skip hoist which unwatered the mine. I believe it was automatically operated, although I am not sure.

Ed. Linders.—I have heard of the water hoist. I believe they have large buckets that drop into a well at the bottom of the mine, and as they drop the bottom of the bucket is arranged so that it will open. The bucket goes down and sinks into the well and is then lifted up, the valve automatically closing and they keep working that cycle. It works automatically, I believe.

A Member.—I would like to ask if any trouble is experienced with the skip rounding curves or jogs?

Fig. 19—Ash Handling Skip Hoist in Connection With Gas Producers

H. V. Schiefer.—The answer to that is yes, any great amount of curve. We find that up to say about 15 degrees we have no trouble, but when we get over 15 degrees we always make the track a good deal heavier at that point and you can always tell if you are looking at the hoisting motor, when the buckets are going around the curve. It seems the curves cause a great deal of friction on the car wheels.

C. O. Palmer.—Do you use flexible couplings in connecting up the motor?

H. V. SCHIEFER.—No. On the hoisting engine frames it is not a flexible coupling, just a regular flange coupling.

A. F. BLASER.—I might ask another question regarding the economy of handling materials in this way, or rather handling them by machinery, and particularly electrically, as opposed to the cost of handling them by manual labor. I am not an electrical engineer, but I have at times tried some figures on the difference between handling materials one way and the other. It seems that a kilowatt hour of energy delivered to a certain point, even remote from the power house, or at least at some distance from the power house, would cost very little, perhaps could be estimated at a cent or a little more, if bought in large quantities. Now, it would seem to me from figures I have made that a K. W. H. should raise roughly 120 yards of material about seven feet. If that were done by men, for instance, shoveling material up on a train where the train is such as is operated by The Cleveland Railway Company, that would correspond to at least two trainloads of material; and you can readily see what a figure it would amount to to have that done by manual labor. It shows a tremendous difference — a penny charge against a great many dollars.

I want to ask Mr. Schiefer whether he has any rough figures of any kind to illustrate this economy, and particularly since some of these sketches show that the skip pit is located so low. It seems that the distance involved in carrying materials by machinery is hardly to be considered. Is that the case or not?

H. V. SCHIEFER.—I can answer that only in a rather indirect way. You have more figures than I have for handling materials by hand or with a train. I call to mind only one particular instance that I am sure of, as to how much it costs to elevate material with a skip hoist. We have figured out to very great length that to elevate coal 150 feet, elevating 750 tons a day at a cost of 1½ cents per ton. Now, if you can compare that with the figures you have just cited, I think that will answer your question.

R. H. DANFORTH.—That is the energy cost alone?

H. V. SCHIEFER.—No, that is the cost of depreciation, energy and crushing.

A. F. BLASER.—I was led to this by a statement I saw in the *Electric Railway Journal* which gave figures on handling materials, and it showed such a remarkable difference that I was very much struck with the illustration. I have kept it in mind ever since, and when I see the sign, "Do It Electrically," I always think of my figures, and particularly of that article in the *Journal.*

R. H. DANFORTH.—There is one thing that does occur to me in connection with the mechanism in the pit, Mr. Schiefer. You have two things that have always been more or less of a bugbear to me in anything connected with automatic or semi-automatic machinery. One is springs, and the other one is those closing gates at the bottom of the hoppers. Don't you have to renew the gates pretty frequently, and don't you have trouble in making them tight after they have been used a little while, and don't your springs give you trouble?

H. V. SCHIEFER.—The material in the pit is made with all of those things in view. For instance, the pins are made of nickel steel. The gate sides are made of steel, in fact, the entire gate is made of steel. There is no cast iron on any of it. As far as the gates wearing out, the sides do wear; but as far as giving trouble, they last for years. As to the springs giving trouble, we have had a little trouble with the springs when a firm would shut down their plant for some time, and then when they go back to start up the plant, the springs would be rusted, or something of that sort, and once in a while a broken spring; but as far

as the trouble is concerned, we have been very much gratified at the results, over the number of years, at the small number of springs broken.

R. H. Danforth.—I had in mind trouble with the springs due to small particles getting in the coils.

H. V. Schiefer.—The springs themselves are quite large, and the greatest amount of material handled, of course, is coal. Coal is so soft that if it does get in the spring it is crushed, and the springs are open and free and the material sifts through.

R. H. Danforth.—You spoke of handling limestone. I thought you might have trouble with that perhaps.

H. V. Schiefer.—We have plants operating on limestone, but I have never heard of that trouble. The men that operate these gates know they have a machine, and it is like all machinery, they have got to watch it, and naturally it is watched, and particularly around the steel mills where everything undergoes a thorough investigation and scrutiny all the time. These things are kept in pretty good condition.

Ed. Linders.—I would like to ask one more question relative to this automatic feature. Do you find any trouble with men not attending to their duties, in the line of oiling and examining, making it a little bit more than human so they do not have to be looked after at all?

H. V. Schiefer.—There is no pin or part in the pit that revolves a complete revolution; it is just a matter of over a little bit and back. There are very few gates that are under 15 x 30 inches in size. They are all quite large, and the levers have large grease cups. If a man does forget to oil them, it does not cause any trouble, unless the plant is shut down for a while, and the pit fills up with water.

Ed. Linders.—I was thinking of the car or engine.

H. V. Schiefer.—The engine itself is in the hands of an electrician.

Ed. Linders.—There is a man there all the time?

H. V. Schiefer.—No, the engine house is usually kept locked. If you go around to see it, you have to round up the electrician to see it. The electrician's duty is to go around and take care of the motor once a day, and take care of the oiling at the same time.

A Member.—These installations seem to be all of pretty large capacity. I would like to ask Mr. Schiefer what he considers the minimum capacity to which a skip hoist is adapted, that is, in which it would pay to install, for instance, for handling coal from hopper cars to a bin.

H. V. Schiefer.—That question, to answer direct, is 60 tons an hour. That is the answer to that question, for coal; but for ashes or other materials, I have seen installations put in where the car would have to operate only two or three times a day, but the material is so abrasive, and people have tried to handle it with elevators, that they have given up on the elevator proposition. The Youngstown Sheet & Tube Company are in that class. If they have anything abrasive to elevate they use skip hoists. They have these automatic types, I suppose almost a dozen having been installed in the last three or four years. The smallest one I have seen installed has been 30 cubic feet. That is simply a proposition for wear, and where it is not an economical proposition from a capacity standpoint.

Thirty-Seventh Annual Banquet of the Cleveland Engineering Society,

Hollenden Hotel Ball Room, June 12, 1917

PRESIDENT'S ADDRESS

F. W. Ballard.—I will not attempt to go into any lengthy discussion of the many activities of the Society during the year. It would be impossible to do the subject justice, not because of your president or any activity on the part of your president, but because of the efficiency of the chairman and the members of the various committees.

As I told you at our banquet a year ago, this is not a one-man organization. It has grown too large for that. It is an organization of our membership as a whole, and particularly the efficient members of the different committees, members of the Board of Directors, and the officials who have been working together during the year most efficiently.

Many of them have been continued from years gone by, and will continue in the work in the years to come; so that any administration, although it might be a cross-section, as it were, of the history of this society, is very little different from the history of any other year, because, as I have been happy to note as years have gone by, there has been a gradual improvement, an enlargement and increase in the activities and in the efficiency of the work which the Society has done. I feel sure that that is going to continue and the work which we have been doing is going to be continued, enlarged upon and improved.

Touching briefly upon the various matters which have received attention during the past year, I would like to mention first and foremost the work of the Library Committee, something which I am sure will surprise you all if you do not already know of it. We have recently received additions which will amount to about 22,000 volumes. Our present library contains, I believe, 6,000 volumes, so that we will have, after this addition, in the neighborhood of 30,000 volumes. That good fortune was brought about by the American Society of Civil Engineers which I understand has recently joined with other national engineering bodies in combining their libraries and has thereupon contributed all the excess or duplicate volumes to the Cleveland Association of the Civil Engineering Society, to be turned over to the Cleveland Engineering Society in trust.

You doubtless remember that I mentioned a year ago our ambition was to have the largest technical library outside of the national societies in New York, of any engineering society and in fact of any local engineering society in this country, and I believe we now have it. We have talked during the year repeatedly and at great length about the possibilities of bringing our library up to what we thought it ought to be, namely, about 100,000 volumes, in order to be complete. We have not abandoned the high expectation of yet doing that very thing.

But we also realize that in order to get that library we must house it, and that started us along the idea of securing a building for the Cleveland Engineering Society, an endowment for that building, and an enlargement for the library. We have been prevented during the past year in launching the campaign, but I hope the plans which we have entertained are not dead, and that they will still be cherished and put into effect by some coming administration. I expect that it will only be a comparatively short time until we have realized our hopes and I think you will hear more about it.

Long before war was declared, the Cleveland Engineering Society was active in supporting Major Bond in promulgating among our members full information in regard to the proposed Engineer Officers' Reserve, and I am happy to say that a large number of

our members—some of them have already received commissions and some are now in the way of receiving commissions—are down at Fort Benjamin Harrison.

The Executive Board took up the question of a Liberty Bond. We wanted to be in on that, to contribute our bit, and do our share. We had put $3,000 in our Permanent Fund, and we obtained the authority to purchase a $1,000 bond from the Permanent Fund. All of you will share in the ownership of that bond.

This last year we have had more meetings of the Society than ever before. We have had 39 professional meetings of the Society and 25 meetings of the Executive Board. You know what has been done in the way of noon-day meetings and luncheons under the leadership of Mr. Protheroe, their efficient chairman.

Among our Officers and our Committees I wish to mention a few of them by name who have been most efficient and have done excellent service during the year. We have had J. H. Stratton, our Vice President and Chairman of the Finance Committee; and I am sorry to say that Mr. Stratton decided not to accept the offer of election for Presidency for the coming year. Naturally, under the traditions of our society, he should have been elected President for the coming year, but Mr. Stratton himself declined the honor for personal reasons, and we have all regretted exceedingly that he could not accept it. However, we are happy to say that J. H. Herron was selected for the position, and he has been elected as President for the coming year.

Mr. Drayer, as Secretary of the Society and Chairman of the House Committee has done wonderful work. I cannot compliment him too highly on the results secured.

Mr. Tinker, our Librarian, has done excellently. Our library has been well taken care of, and it was largely through the efforts of Mr. Tinker that we secured the addition that I have just told you about.

Mr. Richards, as Chairman of the Membership Committee, has done splendidly. His Committee has been very efficient.

Mr. Thomas and the Program Committee I don't need to mention. You know what has been done by the Program Committee during the past year; and in view of the largely increased number of professional papers that had to be provided, it has been a man's job. I am glad to know that Mr. Thomas is going to be your Vice President next year.

Mr. Clegg of the Publication Committee has done most excellent work. Mr. Clegg has done something within the last week that I think should be chronicled. He has held some conferences with Mr. Brett, the City Librarian. Due to these conferences, Mr. Brett agreed to go to New York himself and personally supervise the packing and the shipment and the classification of 22,000 volumes to see that they were brought here in good shape, and he is going to personally see that those boxes are stored and taken care of until we are able to provide for them. I want to tell you that it is some problem to take care of 22,000 volumes. We are very fortunate in having offered to us the assistance of Mr. Brett who transferred from the old Public Library Building to the temporary building which the Public Library in the City of Cleveland now occupies, 40,000 volumes in one night. Those volumes as they stood on the shelves in the old building in the evening were in shape the next morning so that when the girls went to work the books were on the shelves in the same order and in the same way and could be given out just as they had been in the other location. The only thing that I could think of when I understood about that was that a man who could engineer such a thing as that ought to belong to the Cleveland Engineering Society.

Now those are the members of our standing committees. The special committees, the committees which have been dealing with civic problems of this city, have been helping to run the city of Cleveland. We have an administration elected by the people; we have a Mayor, a Council, etc., but I want to tell you that it needs the assistance of the members of the Cleveland Engineering Society to properly run this city.

Mr. Wilson, Chairman of our Acquaintance Committee, you all know him and the work he has done, and it is unnecessary for me to elaborate on that.

Mr. Linders with the other members of the Auditing Committee has done remarkable work, for it is some job to audit the accounts of the Cleveland Engineering Society.

Our Aviation Committee, Mr. Gammeter as Chairman, has done excellent service and I can say the same of the Bridge and Grade Crossing Committee, with Mr. Newton as Chairman.

I wish I could take the time to enlarge tonight and explain to you the work that has been done by the building code committee under the leadership of Professor Danforth. Due to the efforts of that committee the ordinance on the plumbing code was put through in much better shape than it ever would have been if it had not been for our committee.

The City Lighting and Heating, with Mr. Kingsbury Chairman, and the City Planning Committee with Walter P. Rice, I could not say too much about. A special meeting of the Cleveland Engineering Society took up the question in regard to the disposition of the Erie Street Cemetery, and our Committee on City Planning has helped to solve that problem. Mr. Rice did some excellent work after that meeting on plans which were adopted for the proper handling and disposition of Erie Street Cemetery, and I believe that his suggestions will ultimately be followed out. The plan he worked out is the right one, and you know nothing is ever settled until it is settled right.

Conventions, with Mr. Rowley, Electrification of Steam Railroads, with Mr. Wallau as Chairman, and the Foreign Engineering Developments Committee have done good work and have made numerous reports to the Society at the various meetings.

The Inter-Society Relations Committee, with Professor Dates as Chairman. Professor Dates has done a great deal already toward bringing about a better understanding, better co-operation between the various societies of this city.

Legislation Affecting Engineering, Monroe Warner as Chairman. It is not always that you can expect work for that committee to do, but I want to tell you when there is work for it to do it is pretty important.

Noon-day Meetings by Mr. Protheroe as Chairman. It is needless for me to explain anything about that. The noon-day luncheons and the programs he has provided all speak for themselves. You cannot compliment him any more than he deserves.

The Publicity Committee, Mr. Parkhurst, Chairman. You who have read the notices in the various daily papers in regard to the doings of the Cleveland Engineering Society cannot understand the work involved or the work that was necessary for the Publicity Committee to do. The newspapers are all friendly, of course, and are perfectly willing and anxious to give as much publicity as they can to the activities of the Society, but let me tell you that newspapers themselves cannot publish articles in regard to the Cleveland Engineering Society unless we furnish them to them in shape suitable for their use. That is the reason that we have had better publicity during the past year than ever before, and the chairman of that committee, Mr. Parkhurst, is entitled to a great deal of credit.

Public Safety Committee, Mr. Skeels, and the Rapid Transit Committee, Mr. Moomaw; Rivers and Harbors, Bridges and Smoke Prevention, by Mr. Newton; Street Paving and Sewers by J. W. Frazier. I want to tell you that there has been some excellent work done by Mr. Frazier's committee. The Cleveland Engineering Society has taken an interest in the question of the proper expenditure of the three-million-dollar bond issue voted for paving the streets of the City of Cleveland, and due to the activities of that committee there has been a great deal of help rendered not only to the city administration but to the community at large, the Civic League and other organizations in regard to the proper manner of handling those funds.

Our thanks are also heartily due to the Committee on Technical Education, Mr. Beahan, and Water Supplies, Mr. Murray.

I have attempted to make my references to all of those matters as brief as possible. I would have dearly loved to spend an hour or more telling about what was done during the past year.

We have done one thing during the past year that we are very proud to have done. We feel that we have done honor to ourselves and to the Society by conferring Honorary Membership upon two of our past presidents, who are not only well known to the members of our Society, and in the City of Cleveland but throughout this country, and in other countries as well. So we are doing ourselves honor when we confer honorary membership upon Samuel T. Wellman and Ambrose Swasey.

It gives me great pleasure indeed to speak of S. T. Wellman, who as a past president of this Society, has loved the Society, and who has done a great deal for it. He has been as regular in attendance as has been possible in later years and has taken interest in the activities of the Society. But what I wish to mention particularly are some of the things that Mr. Wellman has done to make his name famous.

He built the first Siemens regenerating furnace in the steel industry. He designed and built the first open-hearth furnace in this country His best-known patents perhaps are the Wellman hydraulic crane and the Wellman open-hearth charging machine, the latter of which made the open-hearth furnace commercially practicable. He patented the rolling open-hearth furnace, large numbers of which are used in this and other countries.

I regret to tell you that Mr. Wellman is unable to be here tonight. Nothing short of sickness would have prevented his being here. He called me on the telephone last evening and said that the doctor absolutely forbade his leaving the house. He practically is confined to his bed at the present time, although I believe that the ailment is only temporary and is not serious. But he told me after I had requested him to come, that he would be glad to write a short letter for me to read to you tonight, and he will be with us in spirit if he is not in person.

LETTER FROM S. T. WELLMAN

June 2, 1917.

F. W. Ballard, President,
Cleveland Engineering Society,
Cleveland, O.

Dear Mr. Ballard:—

I received your letter of June 9th, and to say that I feel highly pleased at the honor you have shown me in making me an Honorary Member of this Society is putting it very mildly, but I do thank you from the bottom of my heart for it. I think it is more of an honor when I consider it to have come after I have lived here most of the time for forty-four years. When a man has lived among you as long as that you get to know something about him. It is also particularly interesting to me at this time, because it is just fifty years this year since I left my

home among the hills of New Hampshire and started for Pittsburgh to get my first insight into the steel business. I have been trying to learn all about it ever since, but what I don't known would still fill a big book.

Perhaps the story of my leaving home at that time might be interesting. My father was superintendent of a small iron works among the hills of New Hampshire, which among other business included the rolling of steel locomotive tires which they made from hammered steel blooms imported from England. To properly heat these blooms they had arranged with C. W. Siemens to build a regenerative gas furnace. The drawings were sent over and turned over to me (who had never seen a drawing of that kind before) to build. My father asked me if I thought I could build the furnace and have it exactly like the drawings. After studying them over a little while I told him that I thought I was equal to the task. He told me to get the furnace built at the earliest possible moment. I had just finished the furnace and had a drying-out fire in it when a big black-whiskered Englishman walked into the office and announced that he was the Siemens engineer who had been sent from England to build this particular furnace. My father turned him over to me to go out into the works and show him where the furnace was to be located, which I did, and my English friend was very much amazed to find the furnace all finished. He was pleased as well, and said, "Why, we have only to start the furnace now, you have made a proper job of building it." So everything else being ready, we started up the gas producers and the furnace and everything worked to perfection. The engineer was so pleased with what I had done that when he left he asked me to go with him to Pittsburgh as his assistant in the starting of a crucible steel melting furnace, which was finished and waiting for him to start. It is needless to say that I did not have to have a second invitation, but went to Pittsburgh with him. This was in 1867, and I spent over a year there. The first few months of that time were spent starting up and operating the first crucible steel melting furnace built in America, at the works of Anderson, Cook & Company. To show what a tremendous saving this furnace was over the old coke-fired furnaces, I will only say that it melted a ton of steel with an average of 1,000 pounds of nut coal which cost less than one dollar, while to melt a ton of steel in crucibles in the old-fashioned coke furnaces took three tons of the very best coke, costing anywhere from two to ten dollars per ton. This style of furnace was a great success, and in a very few years had driven the coke furnaces out of use.

From Anderson, Cook & Company I went to Singer, Nimick & Company's works, where I built two crucible steel melting furnaces of the same type as the one which I went to Pittsburgh to start. After that I spent some time in the office of the Siemens agents in Boston, and also at steel works in different parts of the country starting crucible steel furnaces of the same type. I then built a crucible steel melting furnace at the Chrome Steel Works in Brooklyn, N. Y., which was a success. From there I went to the Bay State Iron Works, in South Boston, Mass. (I having separated myself from the agents of the Siemens furnace some time before this), where I built the first open-hearth furnace that was a commercial success in the United States. This was a pronounced success in a great many ways, making a quality of steel which up to that time had not been reached in this country. The principal use to which it was put at that time was in the manufacture of locomotive fire boxes. From there I went back to the old works in New

Hampshire where my father was still superintendent, and built for them an open-hearth furnace, a plate rolling and bar rolling mill.

I then came to Cleveland in 1873 to design and build the Otis Steel Works, with which I was connected as Engineer and Superintendent for sixteen years. It is useless for me to say very much about the history of the Otis Steel Company, as it is too well known here. But there are two inventions which I worked out during the time I was connected with the Otis Company that are today absolutely indispensable to the economic operation of any open-hearth steel works. I refer to the open-hearth charging machine and the use of the electro-magnet for handling pig iron and scrap steel. Just a few figures will give you a little idea of their importance to the trade and what they are saving every day.

There were made in this country in 1916 approximately thirty-nine million tons of pig iron and about the same quantity of steel ingots of all kinds. Very conservative figures show that at least half of this, or say twenty million tons was pig iron and scrap handled and used in open-hearth furnaces. This was all handled by the open-hearth charging machine and electro-magnet at least once, the bulk of it twice, and a great deal of it three times. By the use of the electric open-hearth charging machine the direct saving in labor is estimated by one of the large users at twenty-five cents per ton. This was about ten years ago, and of course labor is much higher today. At the same time he estimated the indirect saving at not less than fifty cents per ton, which gives a saving in handling of the material charged into the open-hearth furnace (calling it only twenty million tons) of ten million dollars. If we go back seventeen years, this saving amounts to not less than eighty-five million dollars. This is a big sum of money, but the estimate is far below the maximum amount which has been actually saved. The saving in labor by the use of the electro-magnet in the United States per year at the rate pig iron and scrap are being handled today is not less than one and a half million dollars. We can very safely say that in the last ten years at least five times that amount, or the sum of seven and a half million dollars has been saved; or a total for both of these inventions of nearly a hundred million dollars—a saving of which any inventor might well be proud. Every open-hearth plant of any size in the world today is equipped with these inventions, and they are considered as much a necessary part of the equipment as the furnace itself.

A quotation from a letter written by H. D. Williams, Pres. Carnegie Steel Co., Pittsburgh, referring to the charging machines reads: "In our Open-Hearth No. 1 plant we have seven 40-ton capacity furnaces served by two of these machines, which have handled from 1897 to 1917 approximately 4,204,800 tons, or 2,102,400 tons each.

"Our Open-Hearth No. 2 plant consisted of twelve 42-ton furnaces to which were added in April, 1901, four 55-ton furnaces. These sixteen furnaces are served by four charging machines, which have handled during years 1895 to 1917 approximately 9,523,700 tons, or 2,380,925 tons each. Figures given for Open-Hearth No. 2 do not include the weight of molten metal passing through these furnaces."

I am extremely sorry that I cannot have the pleasure of being with you tonight, but I hope that the few facts which I have given you may be interesting.

With best wishes, I am,

Sincerely yours,

(Signed) S. T. WELLMAN.

And now I have the honor and the pleasure of telling you about a certain man whom this Society has come to love and to venerate, and we are glad for the privilege of doing

him honor; in fact, I am not so sure but that the honor is all to us. Ambrose Swasey, not only a past president of our Society, but he is a past president of The American Society of Mechanical Engineers, and I am glad to say that he has been made an honorary member of that society. Mr. Swasey has invented and perfected the epicycloidal milling machine process for automatically cutting spiral gears, the Swasey rangefinder which the government has adopted and which is used in the war department so extensively today, as well as many instruments of precision for use in coast defense work. In connection with Mr. Warner, his partner, he built the large 72-inch reflecting telescope for the Dominion of Canada. He perfected an instrument capable of automatically dividing circles up to 40 inches in diameter with an area of less than one second of an arc. I am glad to say that Mr. Swasey is able to be with us tonight, and will give us a short address.

AMBROSE SWASEY

Mr. President; Members of the Society; Dear Friends:

I am glad to be with you tonight. I am always pleased to meet with the Society, and sincerely regret that for a few years past I have been unable to attend the meetings as often as in former years.

This evening my mind goes back to the time when I joined the Society in 1882, two years after its organization, and I remember well those splendid men who were connected with it at that time. Many of them have gone to their eternal homes, but their memories still live with us, and the influence of their lives will continue for generations to come. We are especially fortunate in having with us this evening some of the organizing members of the Society.

I appreciate the honor you have conferred upon me this evening all the more because it has come to me in my own city from my own people, and from those with whom I have been associated for many years. I am proud to be counted among those who form the honor roll of this Society, and I especially appreciate being associated tonight with my good friend Wellman in receiving this honor. We have been close friends and near neighbors ever since I came to this city in 1881. We have traveled much together in this country; in Europe and in the Orient. We have many interests in common, and this Society is not the least of them. We were born in the same state, down in New Hampshire, only thirty miles apart, and now I will tell you something of a secret. We were born only three months apart, but I was born first, and that is the only time I ever got ahead of him.

We have heard something said tonight of Mr. Wellman's inventions, and I think it very proper that I should mention here my visit in January of this year to the great steel works in China, six hundred miles up the Yangtse River.

The manager of the works, Dr. Woo, who I may say is a very able, efficient and noble-minded man, in showing us the more modern equipment of the plant, pointed out to us several of the Wellman charging machines. I said to him, "Well there is some of the work of my dear friend Wellman away up here in China." As we stood there, and saw those machines operating—the strong arms going into the fiery furnaces and handling the great pieces of steel in an almost human manner, I thought of the great service Mr. Wellman has rendered this country and the whole world through his inventions.

Friends, the history of this Society from the time of its organization to the present is, to a very great extent, the history of modern engineering. And think of the advancement that has been made in that period. With my friends, Mr. J. A.

Brashear, of Pittsburgh, and Mr. John R. Freeman, of Providence, both Past Presidents of the American Society of Mechanical Engineers, last winter I visited China, Japan and the Hawaiian Islands, and we were all particularly impressed with what had been accomplished in those countries in the engineering profession. It was a great pleasure to us to meet the engineers and to learn of their problems and achievements. The night before we left Japan a dinner was given us by a large number of engineers of that country. Nearly all of them could speak the English language, and many of them had been in America and studied our methods. When in Honolulu, we were met by representatives of the engineering society and were entertained by them nearly a week. We realized as never before the importance of the engineer in laying out and operating the great sugar plantations. We learned that in some of the most modern sugar mills, the work is carried to such a degree of perfection that 98 per cent of the sugar is now extracted from the cane.

Wherever one goes it is the same story of the advancement of the engineering profession.

Sometimes it would seem as though this great conflict in which we are now engaged is a war of engineers, and we can hardly realize how much is expected of them. I need not go into detail, for you all know what is being accomplished on the field; in the trenches; in the air; on the water and under the water. You also know the importance of the engineer to our government in an advisory way. In the present crisis he has been called upon to take part in the survey of industrial resources; the Council of National Defense; the National Research Council, and only recently, three men, distinctively engineers, have been appointed as members of the National Academy of Sciences.

As I said, gentlemen, the work of the engineer is on a higher and nobler plane than ever before, and that should be very encouraging to you young engineers. We must depend upon you, and there is a great future in store for you in war or in peace, and I am sure whether it is war or peace, you will ever stand ready to do your part.

Friends, again I want to thank you for this honor. It is indeed an expression from you which I greatly appreciate.

MR. BALLARD.—I have known your President elect for a great many years, both as a neighbor and as an associate in the work of this Society. I heard him make an expression a few moments ago. I do not think he had any idea that I was going to repeat it, and that is the reason I am going to tell it to you. He said, "Well, if I had to give up anything, I would rather give up my membership in the National Society than in the Cleveland Engineering Society; and I believe that in iself is a sufficient introduction for your new President, Mr. J. H. Herron.

J. H. HERRON.—Mr. President; gentlemen: It is a great honor to be elected to the Presidency of the Cleveland Engineering Society. We have evidence of it here tonight when we consider the eminent men who have occupied that position—Mr. Wellman, Mr. Swasey, Mr. Rice, who is with us at the speakers' table, and Mr. Ballard. Therefore, you can readily see that I am greatly honored indeed by election to the Presidency of your Society. In addition to one of responsibility the office may be one of great pleasure as well, and I am entering upon this administration knowing that members of the Society will stand behind me as they have stood behind my predecessor.

The position of the Cleveland Engineering Society as a local engineering society is unique. It is decidedly progressive. It is an upsetter of precedent; and by the way, this year we

hope to upset some more precedents, since the more that we can upset, sometimes, the better.

We have much work before us, notwithstanding the fact that we are probably leaders in progressive thought along local engineering society lines. The situation now confronting the country will put an additional burden upon us all. We who remain at home must assume the burden of those who are in the field, and this should be borne in mind so that we shall carry on the work of this society in the way that it has been carried on in the past, showing progress notwithstanding the fact that our ranks may be considerably thinned by men at the front. And we should do them honor by maintaining the integrity of our organization.

This year we begin, for the first time, an increase in our dues. Some of our members were opposed to this increase. They were perfectly sincere in such opposition, but the majority decided that to carry on the activities of the Society as should be done we should have more funds at our disposal. I am happy to say that even those who did not approve of such action have gotten behind the Society and are not letting the fact that their will did not prevail interfere with their activities, and the Society is to be complimented upon the broad spirit manifested. These men are splendid fellows and men that we desire to remain in our Society. The work will be carried on very much more efficiently with the additional funds at our disposal.

This Society reminds me of a group of business men in this state. Five brothers have a manufacturing establishment which has reached large proportions. They meet and discuss the policies of the business, and the policy adopted by any three is carried out whole-heartedly by the five. They have not only built up a splendid organization, but they have met with financial success.

The Nominating Committee of this Society is an important committee. I might say that possibly they have made a mistake this time. We hope not. The end of the year will demonstrate that quite conclusively. Each one in this Society should consider himself a potential member of the Nominating Committee, and should look about durin the season and weigh the material that we have available for positions in the Society.

We might say that all the members of this Society are unofficial members of the Program, Membership and Acquaintance Committees. So let all of you think of the programs that might be of interest to you, and call the attention of the Chairman of the Program Committee to such subjects. Let all of you act in securing members. At the same time, let all extend the open hand of fellowship to your fellow engineers, not only those who are permanently in our midst, but those who come to us from the outside as strangers. This last is extremely important. We should build our Society along social as well as technical lines. If we neglect the social, we neglect something that is essential to our success. We must have the social properly compounded with the technical.

We should make this Society from now on, as it has been made in the past, stand for progress and of so much importance and interest that engineers in this community cannot afford to be without it, and that engineers from outside would feel it a privilege to become members of it.

I have one thing more that I wish to give you, and that is the announcement of the chairmen of some of the committees. The idea is to have these committees start work at once so that they may be well organized by the time our fall activities begin.

Membership Committee, Mr. G. F. Collister.

Program Committee, Mr. A. H. Bates.

Acquaintance Committee, Mr. J. B. Clough.

Aviation Committee, Mr. H. C. Gammeter.

Bridge and Grade Crossing Committee, Mr. J. R. Poe.

Building Code Committee, Mr. A. F. Blaser.

City Planning Committee, Mr. Walter P. Rice.

Committee on Legislation, Mr. Monroe Warner.

Committee on Professional Ethics, Mr. David Gaehr.

Committee on Publicity, Mr. R. W. Parkhurst.

Committee on Public Safety, Mr. C. T. Harris.

Committee on Public Utilities, Mr. F. C. Moore.

Committee on Rivers and Harbors, Mr. E. B. Wight.

Committee on Smoke Prevention, Mr. J. H. Tufel.

Committee on Technical Education, Mr. Willard Beahan.

Committee on Street Paving and Sewers, Mr. J. W. Frazier.

Your President will add to the committees as occasion requires. We wish to spread the activities in this society amongst as many of our members as possible.

F. W. Ballard.—Knowing that our next topic is on the war, and I happen to see before me at the table one of our members who is a native of France, who took part in the Franco-Prussian War, and who was a member of the French Engineers at Metz. I wish Mr. A. A. Honsberg would stand so that the members can see him.

A. A. HORNSBERG

"The War in the Air", by Mr. G. Douglas Wardrop, editor of the *Aerial Age*. Mr. Wardrop, I understand, has some interesting moving picture scenes which have been taken recently at the front. Before I permit him to proceed, I wish to read just one verse, it will be a short one, from Tennyson. I do not know just when Locksley Hall was written, but it was written when Tennyson was twenty years of age, probably seventy or eighty years ago, before anyone ever dreamed of aeroplanes. There is a prophesy in that verse which I think is wonderful in the light of present developments, and the fact that the dominance of the air will undoubtedly be the controlling factor and the winning factor in this war. If you will bear with me, I will read:

"For I dipt into the future, far as human eye could see,
Saw the vision of the world, and all the wonder that would be;
Saw the heavens fill with commerce, argosies of magic sails;
Pilots of the purple twilight, dropping down with costly bales;
Heard the heavens fill with shouting, and there rain'd a ghastly dew
From the nations' airy navies grappling in the central blue."

Is there anything more wonderful than that prophesy? I do not know what it could be. And the next verse following it contains another prophesy which I, for one, believe will follow immediately after in the realization.

"Till the war-drum throbb'd no longer, and the battle flags were furl'd
In the Parliament of man, the Federation of the world."

I have great pleasure in introducing to you Mr. Wardrop.

THE WAR IN THE AIR

G. Douglas Wardrop.—Mr. Chairman, and Engineers. Before I speak of the war in the air, I want to say that I have attended many meetings of engineering bodies and many annual meetings where reports of progress have been submitted, but without any exaggeration I have not attended a meeting where there have been presented so many reports concerning such diverse activities and showing such consistent efficiency throughout as your president has presented tonight. I believe that if the Cleveland Engineering Society decided day after tomorrow to change its name, a very

appropriate name might be found in "The Super-Council of the City of Cleveland".

It matters not how efficient an administration you may have, it is well for the men in power to realize that back of the scenes there are men whose interests in the city make their interest a keen one in civic and local affairs; and when the city administration and its various members realize that you men are looking at their doings with eyes wide awake and tongues ready to give utterance to your thoughts, the chances are you will have a better administration than you would were you paying attention only to your engineering problems.

The verses which we heard from Locksley Hall were a wonderful prophesy written some hundred years ago, and being realized today, or rather, about to be realized. And I believe that America is going to be the nation which will offer the last unit in the securing of the condition prophesied in the last verse read.

When I spoke in Cleveland three months ago, I stated that a number of authorities had gone to Washington with a program calling for 10,000 aeroplanes. Tonight I am about to state that a different state of affairs exists in our capital, and only on Friday of last week our secretary of war, with whose ability you are all familiar through his association with your city, and Brigadier General Squire, the efficient head of aviation in the army, have got their O. K. to a program of aeronautical activity, which will immediately set about securing for this country as quickly as possible 100,000 aeroplanes.

I know that the most unappropriate thing that a speaker at a banquet can do is to introduce statistics into an address, but I feel as engineers you will want in the briefest fashion possible one or two figures concerning aero progress during the past two years.

When the war broke out, there were possibly existent in Europe something less than a thousand aeroplanes. Three days ago I talked with a man who had just returned from the front, who had had an opportunity to go into details concerning how many machines of the various types were in use on the war fronts, and he stated that he had absolutely reliable information which made him believe that there were on the frontiers of Europe, including all of the nations at war, something in advance of 200,000 aeroplanes and dirigibles.

The actual campaigning of the air started with a few scattered machines going over French lines. Today fleets of aeroplanes soar over the enemy's position invariably numbering from fifty to a hundred per unit, and the latest reports state that each airman in his ordinary activities—each unit of airmen usually consisting of fifteen men—invariably makes 130 to 145 flights per day, and each man is supposed to drop on enemy territory an average of from 75 to 100 pounds of bombs per day. You can easily imagine the effect of that campaign carried on to an even greater extent, and with the participation of America in this war in the air which is now contemplated, and which is about to be carried out, we can see that the military authorities who have stated during the past six months that the way to help our allies most efficiently is to take to them the weapon which will secure for them early supremacy. The moment the enemies of our allies and now our own nation are blinded in the air, it will mean that all of the genius which has gone to the war, the manufacture of heavy artillery, will be at naught. It will be impossible for them to calculate accurately where the gun fire should be directed, and on the other hand, from the other side of the trench lines will come accurately directed fire and incidentally heavy bombardment from the air itself.

Today aeroplanes go over enemy positions as a fleet did on the water hitherto. A speed scout goes out in front in reconnaissance. Following is the two-place tractor bi-plane, a

man with a rapidly firing gun firing directly in front, and sometimes even the pilot has a gun which he fires automatically. In the rear are motor machines carrying sometimes tons of bombs, and again in the rear are speed scouts patrolling in parallel formation and bringing up the line of attack. Therefore you see the tactics in the air are what they were on land and on the ocean when the war broke out, and the weapon that has taken the place of the horrible gasing machine comes from the air. Today the trench lines are covered with smoke thrown from heavy shells, and when that curtain of smoke has been thrown over the trenches, enemy air craft with guns directly in front fly over those trench positions, usually flying at a height of from 500 to 1,000 feet, and those guns, operating at the rate of 600 bullets per minute, fly over the trenches and riddle the trenches with bullets.

That type of campaign, magnified by the introduction into the European war of 100,000 aeroplanes made in this country, will easily, as can be seen by a layman, bring to a rapid termination the conflict now being waged there. And the question which arises in the layman's mind, the man who has hitherto been content on peace, is what will be done with those vast machines after the war ends? An answer is being given to that at this precise moment in the City of London, where there is a conference meeting of representatives of Canada, Australia, New Zealand and the British Dominions, where they are deciding to what purpose the aeroplanes will be put after the war. The foresightedness of the program strikes the business men. Here is a vast organization.

In Great Britain, when the war started, there were 37 companies devoting their entire activity to aeroplane production. What do we find today? Nine hundred and sixty-three concerns are devoting some part of their activity to aeroplane and dirigible production; 360 companies are devoting all of their activities to the production of aeroplanes; and in the environs of London and its metropolitan district there are half a million women who are turning out wings and spars and various parts for the aeroplanes that fly over to France.

When the war ceases, the vast body of people and the vast industry must be taken care of, and so plans are being laid out for aerial mail in Canada and in Australia, where the distances are similar to our own, and in some of the remote parts of Africa, where today aeroplanes are flying over the country that hitherto has only been ravaged by savages. There is not a single country in the world today that is not being traversed by air route.

It is up to us in this nation also to look ahead and to provide the post office department with the machines for which they have been clamoring for two years. An organized plan must be laid down. We have succeeded in getting the authorities to recognize the demand for war machines, and after the war we must extend our utility and utilize the machines in commercial pursuits; and I believe the aeroplane and the dirigible will be one of the most important weapons in bringing about the desired peaceful federation of Locksley Hall poet.

The aeroplane with its route free and untrammeled will go from country to country; and if we had had greater social intercourse and understanding between the countries at war, I think the war would never have occurred.

A journey from the Atlantic to the Pacific coast will be made in a comparatively few hours. The journey from New York to London, I believe, today is a possibility within the 24 hours. Immediately after the war is over, I believe that air vessels will make the journey from London to New York, and indeed around the world, on schedule time, and all as a result of the incentive of war activity.

To thoroughly appreciate aerial warfare, a pictorial presentation is the best, and consequently I will show

you first one or two of the preliminary pictures, and afterward take you by stereopticon slide and motion picture through every one of the phases of the war in the air as it is being practiced in Europe today.

Ed. Note:—Mr. Wardrop here showed a number of interesting slides and moving pictures from the European front.

Society Notes.

AUDITING

ED. LINDERS, Chairman

J. B. CLOUGH HOWARD M. WHITE

Cleveland, Ohio, May 31, 1917.

Executive Board,

The Cleveland Engineering Society,

Cleveland, Ohio.

Gentlemen:

In accordance with your instructions, we have audited the books of account and record of THE CLEVELAND ENGINEERING SOCIETY, Cleveland, for the year ending May 31, 1917, and submit herewith our report.

We verified CASH ON DEPOSIT on May 31, 1917, by the pass books and statements from the depository banks. All recorded CASH RECEIPTS for the period were traced by us into the bank deposits. We found all recorded disbursements through the bank were supported by officially signed and properly endorsed checks on file, and were further supported by invoices, receipts and other proper data, also by authorization in minutes of meetings of Executive Board.

WE HEREBY CERTIFY that in our opinion, based upon the records submitted and information furnished, the annexed balance sheet is properly drawn up so as to correctly set forth the financial condition of the Society at the date named and the relative operating statements are correct.

Very respectfully submitted,

Auditing Committee.

BALANCE SHEET

The Cleveland Engineering Society, Cleveland, Ohio, May 31, 1917

ASSETS:			
Permanent:			
Furniture and Fixtures, Library Equipment, Books		$5,181.56	
Current:			
Cash on deposit:			
Checking Account	$ 14.23		
Commercial Interest Fund	15.70		
Library Fund	21.90		
Permanent Fund	3,898.54		
Student Loan Fund	731.31		
On Hand (Petty Cash)	50.00	4,731.68	
Accounts Receivable:			
Advertising	1,062.75		
Delinquent Dues	31.00	1,093.75	
Promissory Note		200.00	
Inventory of Cigars		27.72	
Total Assets			$11,234.71
LIABILITIES:			
Current:			
Accounts Payable		3,739.73	
Nominal Surplus		7,494.98	$11.234.71

ACQUAINTANCE

H. M. Wilson, Chairman,

J. I. Barry,	C. T. Harris,
H. E. Brown,	L. H. Miller,
J. B. Clough,	E. M. Mohrman,
D. S. Cole,	J. F. Mullin,
K. A. Domino,	C. C. Smith,
Ford Donley,	F. B. Wiegand,
H. B. Fay,	I. M. Williams.

Owing to the numerous outside interests many of the members of the committee were unable to give as much time to this work as they would have liked. However, everyone did his "bit", and there were very few of the luncheons and meetings at which two or more of the members of this committee were not present and in evidence. The work necessarily had to be divided somewhat and the individual assigned to whatever work he could best do. Several of the men willingly assumed some very hard service and carried it out quite well. Others took care of other forms of acquaintance work for which they could spare the time.

It is the suggestion of the committee that permanent tags or badges be secured as soon as possible and that suitable arrangements be made to have them properly taken care of. It is also suggested that early in the year an acquaintance meeting of some sort be arranged for.

AVIATION

H. C. Gammeter, Chairman,

H. L. Asset,	J. E. Washburn,
H. H. Lind,	G. F. Wilson.
John Sinclair,	

The Committee on Aviation desires to report that during the past year an increasing interest has been shown in the field of aeronautics, due largely to the phenomenal progress made in Europe in this line of endeavor during the present conflict.

The rapid evolution of the aeroplane and submarine have revolutionized the methods of modern warfare and Congress is beginning to appreciate the necessity of a keener activity in aeronautics than in the past. Although the success of the flying machine is due to American inventive ability, its practical development has been very rapid in Europe owing to the encouragement of the various governments in which respect our own has in the past been very remiss. The unquestioned growth of this branch of engineering in the immediate future would justify the Society giving it earnest and careful consideration as Cleveland presents many advantages in the manufacture and development of aeronautics.

The Committee feels that the time has come for us to be more closely affiliated with this work and plan to have papers on the subject at frequent intervals. A step in this direction was taken in March when an instructive talk on the aeroplane in modern warfare was given before the Society by Mr. G. Douglas Wardrop, Managing Editor of the Aerial Age Weekly, in which much interest was shown. Arrangements were made to have the same speaker with us at annual meeting and his subject was of great interest to the members.

BRIDGE AND GRADE CROSSING

E. J. Newton, Chairman,

W. P. Brown,	L. V. Gaylord,
C. H. Christian,	H. E. Culbertson.
S. W. Emerson,	

Briefly the progress of grade elimination and the building and repair of important bridges during the year, both in the city and the country, is as follows:

Clark Avenue Bridge is now nearing completion and the floor is being laid. Lower West Third Street Bridge has been replaced by a new plate girder span. Extensive repairs to Upper West Third Street Bridge have been completed. Disposition of Superior Viaduct, after the completion of the new Detroit-Superior Viaduct, has not been decided. Extensive alterations and repairs will be necessary. The city has made extensive inspection and necessary repairs to various important bridges.

The Brooklyn Viaduct has been completed and both roadways put un-

der traffic. The Detroit-Superior Viaduct is practically completed, except for the paving and subway approaches now under construction. The county has also built several important concrete bridges on country roads.

On the line of the New York Central, 105th Street Bridge is under construction and legislation has been passed providing for the elimination of grade crossings at East 49th and 72nd Streets.

The Nickel Plate is now constructing the bridge to eliminate the grade crossing at Ivanhoe Road and has also commenced the extensive work from Fulton Road to Detroit Avenue.

The Pennsylvania Lines have eliminated the grade crossings from Hamilton to Central Avenues and the preliminary engineering for the elimination of grade crossings from Central to Holton Avenues has been done.

On the line of the Wheeling & Lake Erie, tentative plans have been prepared for the elimination of grade crossings at Broadway and East 93rd Street.

On the line of the Erie, legislation has been introduced leading to the separation of grades from East 55th Street to the easterly limits of the city.

The Big Four has started work on replacing the existing swing span over the Cuyahoga River near Cincinnati Slip.

On the line of the Cleveland & Youngstown, work is progressing on all of the structures from their terminal to the easterly limits of the city.

CLEVELAND & YOUNGSTOWN BRIDGES

Bridges East of and Including Woodhill and Buckeye Road.

The bridges east of and including Woodhill and Buckeye Road carry the city streets over the four tracks of the C. & Y. Railroad. There are at present two tracks, but provision has been made for four tracks. These bridges are: Lee Road, East 121st Street, East 116th Street, East Boulevard (East 110th Street), East 103rd Street and Woodhill and Buckeye Road. These six bridges are reinforced concrete slab and beam type, supported on reinforced concrete columns and have concrete railings with brick panels.

Bridges West of Woodhill and Buckeye Road

West of Woodhill and Buckeye Road the tracks of the railroad are above the streets and are:

1st. AMBLER ROAD.—Double track through plate girder span with steel I-beam floor, encased in concrete with ballast under ties. Girders are supported on steel columns on the curb line of the street.

2nd. MCCURDY STREET.—Two span reinforced concrete arch bridge with earth fill. This bridge forms an approach to the steel spans carrying the C. & Y. tracks over the Cleveland Short Line.

3rd. OVER CLEVELAND SHORT LINE.—Double tracks through steel truss span over C., S. L. Railway tracks and double tracks through steel girder approach span with open floor and timber ties and concrete pier and abutments.

4th. EAST 92ND STREET.—For passenger tracks, a double track reinforced concrete ribbed arch span over East 92nd Street. For freight tracks, a double track through steel plate girder span with I-beam concrete floor with ballast.

5th. OVER EAST 90TH STREET AND BOLTON AVENUE.—Forming approach to Pennsylvania Railroad, two passenger tracks carried by double track reinforced concrete ribbed arches. For the two freight tracks there are double-track reinforced concrete ribbed arches over East 90th Street and up to Holton Avenue, and steel deck girders with concrete floor over Holton Avenue and up to Pennsylvania Railroad. Holton Avenue now crosses Pennsylvania tracks at grade but will ultimately be carried under tracks by

the Pennsylvania; this structure has been built with this in view.

6th. OVER PENNSYLVANIA RAILROAD.—Four tracks through riveted steel truss span on concrete abutments.

7th. EAST 83RD, EAST 81ST, EAST 79TH AND EAST 75TH STREETS.—Four-track steel deck girder spans with I-beam concrete floor carrying ballast for ties and with concrete abutments. Bridges at East 83rd, 79th and 75th Streets have steel columns at curb line of the street.

8th. KINSMAN ROAD.—Temporary wooden structure carrying Kinsman Road over the C. & Y. tracks to be replaced by permanent structure when final conditions can be determined.

9th. EAST 55TH STREET.—Present East 55th Street viaduct to be changed to suit proposed track layout under viaduct.

10th. C. & Y. CROSSING OVER NICKEL PLATE.—Double track steel through plate girder bridge carrying freight tracks and four passenger tracks over six tracks of the Nickel Plate Railroad. Bridge floor I-beams encased in concrete carrying ballast under ties. Masonry of this bridge is under construction and the steel superstructure fabricated ready to erect. This bridge has 20 degree skew and has concrete abutments with steel columns encased in concrete between Nickel Plate tracks.

11th. EAST 37TH STREET.—Carries two freight tracks and four passenger tracks over East 37th Street, consisting of deck plate girders with I-beam floor encased in concrete with ballast, carried on concrete abutments. Freight track masonry is complete and the passenger masonry is under construction.

12th. EAST 34TH STREET.—Steel plate girder spans with concrete floor carrying four freight tracks over East 34th Street. Concrete abutments and steel columns at curb line, also steel deck plate girders and I-beam floor encased in concrete with reinforced concrete approaches and steel piers encased in concrete carrying East 34th Street over C. & Y. and Nickel Plate Railroad. Freight track masonry is complete and temporary wooden structure carrying city traffic until permanent structure is completed.

13th. EAST 30TH STREET.—Steel plate girder bridge with concrete floor supported on concrete abutments with steel curb columns carrying Mayflower Road and C. & Y. Railroad tracks over East 30th Street. The masonry is complete.

14th. BROADWAY.—Deck steel girder bridge with I-beam floor encased in concrete supported on steel bents encased in concrete, carrying Broadway over Nickel Plate and C. & Y. Railroad tracks. The old structure has been removed and the sub-structure is under construction.

BUILDING CODE

R. H. Danforth, Chairman,
A. F. Blaser, H. E. Mertens,
H. J. Luff, K. H. Osborn.

The Committee has been fortunate in being able to work in thorough harmony with the City Building Commissioner, and with the Joint Building Code Committee, of which your Chairman has been a member, ex-officio, and has for the most part been able to maintain satisfactory working relations with the Building Code Committee of the Cleveland City Council.

It has not deemed it desirable to originate new legislation during the year, but has been very busy in examining and reshaping ordinances introduced by others, endeavoring in all cases to have the ordinances as passed shaped to conserve the interests of the general public, curbing the efforts of manufacturers, dealers, contractors and organized labor to secure special favors in the form of mandatory or prohibitory ordinances, at the expense of the house or building owner.

During the year your Committee has passed upon the following legis-

lation: A revision of the Plumbing Code; a revision of the Electric Wiring Code; a revision of a portion of the Tenement Code, governing stairways and exits; a revision of certain sections of the Heating and Ventilating Ordinances.

We are now engaged in the revision of the portion of the Building Code governing Reinforced Concrete in Building Construction. This last will not be finished before fall.

The Plumbing Code, as passed, was not wholly satisfactory to your Committee as it barred several economical and labor-saving forms of construction, which have been found eminently satisfactory in other cities and by the U. S. Government.

New legislation is now being prepared by one of our members to correct this, and we urge that every individual member of the Cleveland Engineering Society support the new ordinance, by personal efforts with his councilman, as soon as it has been introduced. Due notice will be given to the Society when this ordinance is introduced.

The Electric Code, the Stairways and Exits Ordinance and the Heating and Ventilating Ordinance have been handled by Council in accordance with our recommendations.

The Reinforced Concrete Code is still under consideration.

Your Committee has held 33 regular meetings with the Joint Building Code Committee, has been represented at eight public hearings of the Council Committee on the Building Code, and has held over a dozen special meetings. Your Chairman has been fortunate in the very active co-operation of the members of the Society upon whom he has called for specialized service in connection with the wide variety of legislation which has been under consideration during the year. The members have given unstintingly of their time and money. One member spent approximately $200 in stenographic and clerical work in connection with the Plumbing Code, and several have traveled to Columbus and elsewhere in the interests of the Committee, at their own expense.

During the year the following members of the Society have served with the Building Code Committee in considering one or more of the ordinances under consideration: H. J. Luff, A. F. Blaser, E. B. Thomas, K. H. Osborn, H. B. Dates and H. E. Mertens.

Several other members have been asked for special advice, which has in all cases been gladly furnished.

CITY PLANNING

W. P. Rice, Chairman,

J. E. Grady, F. A. Pease,
M. H. Horvath, F. W. Striebinger,
F. C. Osborn, Ambrose Swasey.

In addition to routine work the two most important actions of the Committee have been the consideration and presentation of plans and proposed solution of the Erie Street Cemetery dispute and the formation of the "Cleveland City Planning Federation", which we would comment upon as follows:

The mooted question as to the advisability of the removal of Erie Street Cemetery referred to your Committee by the Executive Board of the Cleveland Engineering Society, received much attention and thought from the members of our Committee, and included a public meeting in the rooms of the Cleveland Engineering Society under the auspices of said Committee, at which both the "Erie Street Cemetery Removal Association" and the "Pioneers' Memorial Association" were ably represented, the attendance being large and the pros and cons being well threshed out.

The Committee later submitted a report, accompanied by plans, which received the approval of the Executive Board. Personally I have always deemed the proposed solution a happy one, and noted a striking confirmation of the Committee's views while in Los Angeles this winter in the pub-

lished accounts and plans of "Improvements Now Going Ahead in Forest Lawn Memorial Park", under caption of "Stately Hall for the Dead". A comparison with the Cleveland plan shows such a strong resemblance as to suggest that both plans were drawn up by the same designer, although such was certainly not the case.

Under the initiative and auspices of the Cleveland Engineering Society, the "Cleveland City Planning Federation" has sprung into being, the original societies or charter members being as follows: The Cleveland Engineering Society; the Cleveland Real Estate Board; the Cleveland Advertising Club; the Cleveland Rotary Club; the Cleveland Automobile Club; the Builders' Exchange, and the Cleveland Section of the American Society of Civil Engineers.

A Constitution has been adopted, and officers elected as follows:

President, Walter P. Rice, Cleveland Engineering Society.

Vice President, Stanley L. McMichael, Cleveland Real Estate Board.

Secretary, George W. Fleming, Cleveland Advertising Club.

Treasurer, John R. Bentley, Cleveland Rotary Club.

Director, E. A. Roberts, Builders' Exchange.

Director, Fred H. Caley, Cleveland Automobile Club.

Director, W. J. Watson, Cleveland Association of the American Society of Civil Engineers.

The following preamble, and resolution of the Executive Board of the Cleveland Engineering Society explain the authorization and reasons under which your City Planning Committee acted:

"Whereas, the question of City Planning now being agitated by citizens of Cleveland generally and various organizations which have voiced the public sentiment by the appointment of committees dealing with this question, is a broad and momentous one depending on the fruition of labors extending perhaps through more than one generation, and calling for vigorous, united and sustained effort on the part of all civic forces.

"Therefore, your committee, with the single view of uniting and co-ordinating the available forces now acting in a more or less desultory and inefficient manner into a harmonious whole with the strength and efficiency which generally results from proper welding and organization, asks the moral support and official sanction of the Cleveland Engineering Society in the attempt to form a permanent Federation or Congress of professional societies and others, to consider all problems of city planning in a general way, encourage the dissemination of knowledge on the subject and to support, encourage and assist the present City Commission appointed by the Mayor of Cleveland, such Federation to be composed of Committees on City Planning or representatives selected by the various organizations.

"Whereas, the City Planning Committee of the Cleveland Engineering Society has been investigating the means to serve the purpose for which it was created,

"And whereas, there exist committees appointed by the different civic organizations of this city for the same purpose as the City Planning Committee of the Cleveland Engineering Society,

"And whereas, these committees are conducting investigations along the same lines as the City Planning Committee of the Cleveland Engineering Society,

"And whereas, the City Planning Committee of the Cleveland Engineering Society recommends the forming of a Federation of City Planning Committees of the different organizations:

"Therefore, be it resolved, that the City Planning Committee of the Cleveland Engineering Society be instructed and is hereby instructed to effect a Federation of the different City Planning Committees of the civic organizations of this city.

"And be it resolved further, that the City Planning Committee of the Cleveland Engineering Society is hereby authorized to represent the Cleveland Engineering Society for the purpose of effecting such Federation, and has the authority to consummate their part for such Federation for the Cleveland Engineering Society."

As affording further light upon the question we beg leave to quote from the Constitution and By-laws of the Federation, its object, as follows:

"The object of this Federation shall be to further the City Planning of a future Cleveland, to assist the municipal authorities and any representative committee they may select in the solution of the many problems called forth in the consideration of city planning. Such assistance may be educational for the passing of judgment upon proposed schemes for future betterment.

"Among the means to be employed for this purpose shall be: Meetings for the presentation and discussion of papers dealing with city planning of the City of Cleveland and its environs, the publication of such papers and discussions as may be deemed expedient; the collection of maps, drawings and models and the establishment of facilities for their use."

In closing it may be stated that the Federation contemplates the addition of other civic societies, at which time standing committees will be appointed. The different organizations will be limited as to the number of representatives and each set of delegates will be entitled to two votes irrespective of membership of organization. The different organizations will undoubtedly be asked to contribute papers on details of Cleveland City Planning which will be discussed.

In conclusion, it is necessary to state that the war activities and general unrest have made it necessary to consider seriously the advisability of pushing city planning at this time. A meeting of the officers of the Federation will have to determine this point in the immediate future.

July, 1917

CONVENTION

C. B. Rowley, Chairman,
C. E. Bill, R. H. West,
J. M. McCleave, J. H. White.
J. B. Meriam,

The Convention Committee extended the privileges of our Club Rooms and welcome to the Ohio Society of Mechanical, Electrical and Steam Engineers, the American Institute of Electrical Engineers, the American Canneries Association and the Alumni of the Massachusetts Institute of Technology during their respective sojourns in Cleveland. Several members of the above associations accepted our hospitality and I believe appreciated the privileges extended.

ELECTRIFICATION OF STEAM RAILROADS

H. L. Wallau, Chairman,
E. H. Martindale, W. G. Stephan,
E. P. Roberts, J. H. Tufel.
R. O. Rote,

The desirability of the electric propulsion of railway trains is no longer open to question.

Its practicability, for heavy main line traffic as well as for conjested terminal work, has been demonstrated by the successful electrification of the mountain division of the Chicago, Milwaukee & St. Paul Railway, and the admirable results obtained in New York City by the New York Central and Pennsylvania Railroads.

The 17,000 miles of electric interurban roads in this country leave no doubt as to its ability to successfully handle moderate high speed traffic under reasonable headway.

If electric power is, as it seems to be, adapted to all traffic conditions, why is it that today there are but some 1,500 miles of steam railroad electrified, totaling perhaps 4,000 miles of single track?

Systems of electrification are not yet standardized. For the same general system, locomotive designs, voltages and other characteristics are different for almost every installation. The trend is toward higher voltages with their inherent economy.

With the steam locomotive, advantage could be taken of each step of development, since outside of the occasional reinforcement of a bridge or trestle, or the increase of an overhead clearance, or other minor changes, the improved type could be immediately put to work without other expense. True, as engines grew larger and consequently heavier, rails had to be changed, but this renewal took place gradually as the lighter rails wore out.

With the electric locomotive, this is not the case to such a degree, because the improvements have, in a large measure, been due to combinations of changes in the units themselves and the character of the system employed.

The majority of the steam roads of the country have, undoubtedly, given much thought to the subject but have been inclined to agree with Pope when he said:

"Be not the first by whom the new is tried,
Nor yet the last to lay the old aside."

And as new developments have been made comparatively rapidly since 1895, when the B. & O. tunnel electrification was first planned, many of the roads have "stood pat".

The business of a railroad is to haul revenue producing loads. The stress of circumstances in the early days compelled railroads to furnish their own motive power. When electrification first began to receive attention, it was but natural that the roads should assume that they must build power houses and transmission lines, as well as distribution centers and circuits, in addition to providing the locomotives. Their power requirements were large, and it was generally argued that a railway could manufacture power in large quantities as economically as a power company and, by so doing, avoid paying a profit over and above cost.

The importance of diversity was recognized as applied to their own loads, but lost sight of in its effect upon a combined railroad and industrial load. That the advantages resulting from this diversity have now been recognized, is shown by the fact that not only many urban and interurban railways now purchase all or part of their power, but that steam roads are now beginning to do the same for their electrified divisions. Railroads no longer need to generate their own power, and they have not been slow to take advantage of this fact. It is a most hopeful sign, since it reduces materially the investment required by a road in order to electrify. This investment, under the most favorable conditions, is of no mean order, and the question of financing such an undertaking often a difficult one.

The electrification of the Butte, Anaconda & Pacific Railway resulted in economies so marked that it was conclusively shown that electrification could be made to pay direct profits on the money invested. These results paved the way for the electrification of the Chicago, Milwaukee & St. Paul, which contemplated a total of 850 miles of main line electrification between Harlowton, Mont., and the coast. The cost for this road is given as somewhat under $30,000 a mile, or about $25,000,000 for the 850 miles planned.

Electrification, prior to the two instances mentioned, have generally been undertaken because local conditions rather forced them on the railroads, and, as a result, have been regarded as a costly luxury, rather than as a means of reducing operating expenses.

In the past ten years, railway earnings have not kept pace with expenses, and present indications are that future expenses will be considerably higher, since both labor and materials are rapidly increasing in cost. It follows that railroads will have to study and put into effect economies far in excess of those deemed necessary in earlier years, and the future of electrification is assured by this necessity, for its advantages have now been thoroughly demonstrated, and railway men are

being fast convinced in this regard.

Now mere convictions on the part of railway financiers will not raise money unless the credit of the roads is what it should be.

But since railroad earnings have not kept pace with expenses, either dividends or surplus, or both, have shrunk. This has impaired credit and investors have not been so ready to take up new issues of railroad securities. What is the solution?

The railway managers say that "if regulation which affects interstate commerce could all be centered at Washington, two grand results would be promised. First, needless duplication of expense to the roads, arising from regulation by 48 states, would be saved to the roads and to the public; second, the Interstate Commerce Commission could then be held responsible for the total financial results of the rates which they fix, and of the expenses which Congress compels, and hence, the country would at all times have a servant whose function it would be to watch for untoward tendencies in condition of the roads and act with promptness and decision in the public interest."

Centralized control and centralized responsibility! It seems reasonable.

Summing up, we may state that:—Electrification is practical and economical. Railroad men are acknowledging the fact. Necessary economies will force electrification, if the necessary capital can be raised. Railroad credit must be improved before the vast sums required to electrify the country's railroads can be secured.

FOREIGN ENGINEERING DEVELOPMENTS

F. A. Vaughan, Chairman,
F. A. Fahrenwald, R. S. Tyler,
J. F. Oberlin, M. W. Zeman.
A. E. Reed,

The Committee worked with two objects in view:

(1) To bring to the attention of the members of the Society items of interest bearing on foreign engineering development work, published in foreign or domestic journals.

(2) To present to the Society at one of their regular meetings original papers covering some phase of foreign engineering methods.

Members of the Committee gave four five-minute talks preceding regular Tuesday evening meetings, presented papers at the regular meeting of March 6th, 1917, and held in addition five meetings in preparation for these papers, a total of thirteen meetings.

The committee has been handicapped in gathering material by the extraordinary conditions of the past year, both abroad and at home. The Committee feels, however, that the field is promising and that future committees, if such may be appointed, can make valuable contributions to the work of the Society.

INTER-SOCIETY RELATIONS

H. B. Dates, Chairman,
F. D. Davis, H. P. Rodgers,
B. L. Green, E. H. Whitlock.
R. S. Mayer,

The Inter-Society Relations Committee has not done very much work of a decidedly definite character, but has perhaps accomplished considerable in an indirect manner.

The committee recommended the interchange of society relations with the Vermont Engineering Society, and suggested that the Cleveland Engineering Society co-operate with several local societies in different matters.

The committee suggested co-operation with the Electric League in a joint committee on the lighting of the new public library. This committee was appointed and has done considerable work in connection with the architects, Walker and Weeks, and the city librarian, Mr. Brett. This work is still under way. It necessarily cannot progress very rapidly, but the committee has made very valuable suggestions to those responsible for the lighting of the new library; and has in hand at the present time the devel-

opment of some special lighting schemes for the reference tables and the stacks. I feel that the lighting committee should be continued as this work is liable to run on for some months to come.

The committee also took some steps to further the formation of a joint committee of the American Institute of Electrical Engineers, the Electric League and the Cleveland Engineering Society, which committee discusses matters common to these three organizations, and acts as a clearing house, as it were, for joint matters. I cannot say as to whether this special committee has done very much work, but it has served at least one purpose, namely, to bring the societies into closer touch with one another.

Your Chairman, also acting as a member of the Electric League, suggested that the Cleveland Engineering Society offer the League members the use of the engineering library under such regulations as were proper, and I believe this was presented to the directors of the Engineering Society and favorably acted upon. In this connection I might say that the Electric League refrained from furthering a movement within the League to form an engineering library at the League, it being thought advisable to co-operate rather than to organize still another library in the city.

LEGISLATION AFFECTING ENGINEERING

Monroe Warner, Chairman,
Harry Fuller, B. A. Stowe,
Robert Hoffmann, H. F. Stratton.
C. W. Hopkinson,

We have no knowledge of any bills affecting engineering being introduced in the legislature of the state of Ohio during the past year.

Within recent years several states have enacted laws affecting engineering, principally by requiring that civil engineers or architects be licensed to practice. In order that those interested may be informed in this matter your Committee has obtained and placed on file laws and data from several states and has prepared a Bill for Licensing Civil Engineers and Architects to be introduced in our State Legislature should such action be deemed best. So far, there seems to be no call for such legislation and your Committee has considered it unwise, at this time, to pursue the subject further.

Minor matters referred to this Committee have been reported out.

LIBRARY

G. H. Tinker, Chairman,
R. J. Clegg, E. H. Whitlock.

The work of the library has been curtailed during the past year by lack of funds. Practically no new books have been purchased. Current periodicals have not been bound. Work on the classified and subject indexes has not been pushed. On account of moving and rearranging books in new quarters, extensive changes in shelf numbers were made necessary.

The increased use made of the library by the members is made evident by the fact that a large part of the attendant's time has been given to finding and collecting material for studies and researches. We have also served a large number of persons referred to us by the Public Library. These readers mostly wished to examine material which is lacking in the Public Library by reason of loss in the bindery fire.

The increased cost of printing stock has caused the loss of a number of exchanges, and the addition of very few. This is the only year in the last nine during which our exchange list has suffered a net decrease.

Negotiations are under way looking to the transfer to the library of about 22,000 items. To house this number will require 315 lineal feet of double-deck stacks. Making the necessary allowance for passage ways will require a stack room about 58 x 20

feet. In planning new quarters for the Society provision should be made for the ready expansion of stack room space to 5,000 square feet. Nearly an equal space will be required for work rooms, indexes and readers' facilities. As the library grows the space required to accommodate the users will increase much faster than the stack room space up to the point where facilities for the maximum number of users shall have been provided.

It is recommended that for the coming year the minimum appropriation be $1,500. This should provide for an attendant upon full time, subscriptions, supplies and binding.

MEMBERSHIP

F. D. Richards, Chairman,

J. H. Alexander,	G. E. Jackson,
M. F. Armour,	W. H. Kast,
G. C. Bolz,	Otto Konigslow, Jr.,
C. S. Boyd,	C. O. Malpas,
Howard Brocklebank,	A. S. Mitermiler,
H. A. Brown,	P. B. Nau,
W. H. Buesser,	V. A. Root,
R. B. Chillas, Jr.,	H. T. Simmons,
W. D. Cleavenger,	H. C. Snow,
A. B. Cook,	R. L. Stern,
W. C. Davis,	A. G. Wallace,
T. M. Focke,	G. W. White,
J. K. Gannett,	T. B. Williams,
F. N. Gilliland,	F. C. Worbs,
B. A. Harman,	Will Zenner.
Roy Husselman,	

The Membership Committee held numerous meetings during the year for the purpose of creating enthusiasm for the work and of devising methods suitable for presenting to prospective members the advantages of membership in the Cleveland Engineering Society. The Committee continued the work laid down by the last Committee at the time of the special effort put forward to increase the membership of the Society. Although each one of the Committee was especially busy, much time was spent in this work. It is apparent that the various local engineering associations should be affiliated to the end that the full effect of engineering opinions for the benefit of our community be secured. Some means should be devised to avoid the statement "I belong to such and such a society and see no particular advantages in joining the Cleveland Engineering Society," as this statement is very frequently advanced by those approached.

During the year the membership was increased by 111 members: Active members, 75; Associate Members, 14; Corresponding Members, 2; Junior Members, 20, making a total increase of 111 in the membership of the Cleveland Engineering Society.

NOONDAY MEETINGS

T. G. Protheroe, Chairman,

J. J. Bever,	H. M. Wilson.
Ford Donley,	F. J. Dresser,
J. W. Macklin,	J. R. Poe.

The Committee had in mind several definite objects to be attained when it started on its work last October. These objects were suggested by the Executive Committee and we have, as far as possible, tried to carry out the Executive Committee's wishes, although our Committee recognized no traditions and followed no precedents.

From October 6 to June 1, 33 meetings were held, with a total attendance of 2,281, an average attendance of 69. The largest attendance was 150 and the smallest 31. There was developed a group of men who were very regular in their attendance and these men, of course, profited most by the efforts of this Committee.

We have experienced no difficulty in getting speakers lined up for the meetings, and were pleased to note the splendid standing in which the Cleveland Engineering Society is held in this community. We were never turned down. On the other hand, we were able to get some of the leading men in this city to attend our meetings and speak to us.

Every meeting was presided over by a different man as far as possible, thus introducing to the members of our Society men who are leaders. The Committee had in mind always the interest of the younger and newer members, although it was difficult to get a very large attendance of these because of the time of the meetings.

The idea was largely an experiment at first, but the splendid co-operation of the members and officers of the Society has convinced the Committee that the effort is worth while and that there is a real need for a feature of this kind. The Committee also wishes to express its appreciation of the courteous dealing accorded it by Mr. G. K. Clark, of the Chamber of Commerce Club.

There are just two suggestions which the Committee would like to make as a matter of record: That next year some definite appropriation be made for incidental expenses, such as printing and advertising. That, if possible, the postal cards which were sent out weekly, be enlarged and put into some bright, newsy, bulletin form, which would not only carry the news of the activities of the Society, but would attract the interest of the members.

PROGRAM

E. B. Thomas, Chairman,

H. E. Baldwin,	W. M. Faber,
A. H. Bates,	J. H. Herron,
H. C. Chapin,	C. W. Larner,
W. N. Crafts,	R. W. Pratt,
H. B. Dates,	F. R. Walker.
Howard Dingle,	

Herewith is a brief report of the work of the Program Committee during the past year. For the purpose of determining the subjects which would be the most interesting, a questionnaire was sent to the members at the beginning of the year asking their preference of the following subjects:

Architecture,
Bridge and Structural,
Chemical,
Civil,
Contracting,
Efficiency,
Electrical,
Gas,
Hydraulic,
Inspection,
Instruction,
Landscape,
Mechanical,
Military,
Mining,
Municipal,
Patent,
Publishing,
Railroad,
Sanitary,
Street Railway.
Surveying,
Water Supply.

The number of meetings and speakers secured during the year was 39. The average attendance at these meetings was 152 plus, while the total attendance for the year was 5,938.

PUBLICITY

R. W. Parkhurst, Chairman,

C. S. Pelton, C. S. Boyd.

J. W. Macklin.

During the past year, the efforts of the Publicity Committee have been directed especially to enlarging the scope of the work in the local field along lines already well established. This has resulted in increased recognition of society activities in questions relating to civic progress.

We are greatly indebted to the local press. During the year, the daily papers have handled about 500 column-inches of meeting notices, reports and other write-ups, and the Sunday papers about 750 column-inches, mostly articles dealing with selected topics.

An additional feature of this year's work has been the separate report of luncheons by afternoon papers and the calendar notices which have preceded all meetings.

Of particular interest both to the local society and to engineers at large has been the special publication, "The Conquerors," prepared under direction of a committee appointed by the President especially for this purpose. The willingness to assist evidenced by professional men and the encouragement given by universities and engineering societies were the factors contributing to make its production possible. Its favorable reception is evidence that a publication embodying its principles of non-technical description

of engineering work might well be successful.

SPECIAL PAVING

J. W. Frazier, Chairman,
W. J. Carter, Willard Beahan.
Dr. C. S. Howe,

Your Special Committee on Paving held several meetings, to one of which the Mayor and Director of Public Service Bernstein were invited to study the paving situation under the special bond issue passed at the November election.

The committee outlined to the Mayor and the Director of Public Service a plan for proper management and economic expenditure under this bond issue, which is embodied in the attached letter to the Mayor and Council. A copy of the letter was sent to the Cleveland papers and to a large number of civic organizations and was supported by nearly all of them, with the result that the Mayor appointed a commission, of which two members of your Committee are members, the other members being representatives of other civic organizations of the city, to be known as a Paving Commission, to act in an advisory capacity to the Director of Public Service and the Mayor and Council in outlining a program for paving and repaving of streets.

The Mayor, however, does not welcome such a commission and although one meeting has been held, the commission has not organized.

January 18, 1917.

To the Mayor and Council,
City Hall,
Cleveland.

Gentlemen:—

Last fall the citizens of Cleveland voted favorably upon the proposal to issue bonds in the sum of three million dollars for the purpose of paying the city's share of paving and repaving city streets. Some of this money will undoubtedly be spent for paving unpaved streets and some will be used for repaving streets where the pavement is now poor. Where streets are repaved the city pays one-half the cost of the pavement and the abutting property owners pay the other half. When unpaved streets are paved the city's share is about ten per cent of the cost of paving while the abutting property owners pay ninety per cent. If all of the money raised from the bond issue, namely three million dollars, was used for repaving, it is evident that the sum of six million dollars would be spent because the city's share is only one-half of the total cost. If all of the three million dollars were used for paving streets that are at present unpaved, the total amount spent for this paving would be thirty million dollars because the city's share would be about ten per cent. As part of the money will be used for new paving and a part for repaving the total amount spent will be somewhere between six million dollars and thirty million dollars.

If we suppose that at least \$500,000 from the bond issue is used for paying the city's share of the cost of new pavements, then the total amount used for new pavements will be five million dollars, as the city's share is but 10 per cent of the total cost. This would leave two and a half million dollars for paying the city's share for repaving. As the city pays only one-half the cost of repaving, the total amount spent for repaving would be five million dollars. It is a conservative estimate to say that \$500,000 of the money raised for paving purposes will be the city's proportion for new pavements, and yet under this conservative estimate the total amount to be spent for paving streets that now have no pavements and for repaving streets where pavement is now poor, will be \$10,000,000. The total may amount to two or three millions more. This is an enormous sum for a city the size of Cleveland to use for paving. It cannot be spent during the present administration nor during the next administration. In fact, the paving program must continue

through four or five different administrations. That is to say, eight or ten years will elapse before all of this paving can be done. In the past it has been found practically impossible to spend more than one million dollars per year for paving and repaving because there have not been paving contractors enough to do more than this amount of work. If in the future we do each year an amount equal to what has been done in the past it will take ten years to spend the ten million dollars which will be available for this purpose. It is evident that under these circumstances neither the present administration nor any other one administration can control all the paving work that is to be done under the present bond issue. *A definite constructive program should be laid out before any work is started.* It would be far better to have such a definite program and to do no paving during the present year than to fail to have such a program and do a lot of paving which would not fit into a proper plan.

When the City of Cleveland was considering the advisability of a group plan of public buildings it was admitted by the city authorities and others interested that the work would last for some years and that it should be under expert control which would not in all probability be affected by different administrations. An advisory board of architects was therefore appointed to which was submitted all the plans which were suggested. No plan for buildings nor for grounds was adopted until it had the approval of this advisory board. Quite a number of years ago it became necessary to adopt a comprehensive plan of sewers in Cleveland and a sewer commission was appointed to make such plans.

The program laid out by that sewer commission is being followed today. *The City of Cleveland has not yet spent in the group plan nor in the sewer plan as much money as will be available for street paving due to the three million dollar bond issue.* A definte plan for paving and repaving should determine the policy to be pursued in the laying of pavements before or after sewers are built, before or after gas pipes are laid, before or after telephone tunnels are constructed, before or after water mains are laid. There should be a definite policy in regard to the construction of curb connections and the relaying of pavements after they have been torn up for changes in sewers, water pipes, gas pipes and telephone lines. At present there are a number of different organizations or firms in the city which, by obtaining permits, may tear up the streets, and, after their work has been done, the city relays the pavements. As a result of this frequent tearing up of the streets and in many cases of incompetent supervision we have many pavements which were laid only a few years ago and which ought to have remained in serviceable condition for years, but which now are a disgrace to the city. This state of affairs is not the fault of the engineering department for it has never been given control of this matter.

In view of all the above statements we would respectfully request the Mayor and Council to appoint a paving commission with all the authority that it is possible to confer upon it, with power to make the rules under which paving and repaving shall be done and whose approval must be obtained before any work can be carried on. This commission should work in conjunction with the city engineer. Such a commission might, in our opinion, be made up in one of two ways. First: It might consist of a board of three expert paving engineers who would give a portion of their time to the City of Cleveland and be paid for their services. It would not be necessary for them to give any time to this service after the general plans were adopted, except at stated intervals when it would be

necessary for them to consult with the city engineer. This plan would be similar to that adopted for the group plan commission and the sewer commission. Second, such a commission might be made up of Cleveland citizens, serving without pay, the majority of them to be engineers, who would give whatever time was necessary. The authority of the commission should in either case be the same. One of the duties of this commission would be to present its findings and its plans in full to the people of the city in order that they might know what was to be done and the reasons why it was to be done. In this way public sentiment would force the continuation of this commission through different administrations.

The present City Engineer has served through several administrations and has been trusted by them all. His work must be, however, to a large extent executive. He has to look after sewers, streets, the repairing of old bridges, the construction of new bridges, and much other civil engineering work which pertains to his office. It is necessary that he have under him thoroughly trained men to look after the various subdivisions of the work. If we are to spend ten million dollars upon pavements during the next few years the city engineer should have as one of his assistants a thoroughly trained and experienced expert paving engineer.

We shall have good pavements or poor pavements as a result of this large expenditure of money according to whether we have or do not have a definite plan under which the work shall be done and a thoroughly competent paving engineer to take active charge of the work. We earnestly hope that the Mayor and Council will take such steps as to place this whole matter upon the firmest and wisest foundation.

NECROLOGY

W. O. HENDERER.

On Friday, the ninth day of February, the members who happened to be in the Society's rooms were shocked by the announcement of the sudden death of our former president, Mr. W. O. Henderer.

Mr. Henderer had been sojourning in Florida during the recent severe weather, enjoying the pleasures of the southern climate. His death was a surprise to all, though it was known that he had suffered considerably of late from injuries received in an automobile accident in December.

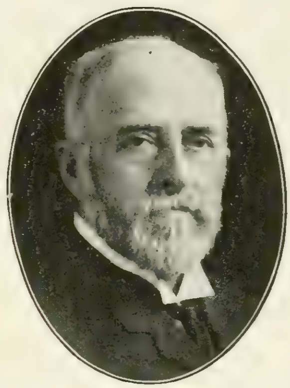
Mr. Henderer was chosen president of the Cleveland Engineering Society in 1913. His administration was marked by great activity on the part of the Society and rapid progress in its development. Mr. Henderer was admired and highly esteemed by a large number of friends and his loss will be felt not alone in the profession but in circles of business and friendship as well. It is, therefore, fitting and with a grateful feeling of remembrance that we offer the following resolution in commemoration of his service to the Society and the misfortune of his untimely end. Resolved:

That in the sudden death of our esteemed fellow member and former president, Mr. W. O. Henderer, the Society has lost one of its most prominent and distinguished members;

That this loss is a great misfortune to the Society, to his friends and business associates and will be felt severely in those activities in which he was wont to join;

That the condolences and good will of the Society are extended freely to the members of his family in their bereavement; and

That it is now desired to display the honor and esteem which it feels for the memory of the deceased by placing this resolution of the Society upon the minutes of the meeting and forwarding a copy thereof to the family.



J. F. BROWN.

Jay F. Brown, civil engineer and land surveyor, born Genoa, Cayuga County, N. Y., Sept. 11th, 1851, died at Cleveland, O., Feb. 9th, 1917.

He worked his way through a normal school in Pennsylvania and engaged in teaching. He attended Cornell University for a year. He came to Cleveland in 1876 and shortly afterward took a position with Aaron Merchant and Corwin C. Merchant, pioneer surveyors, with whom he remained for several years. In 1881 he was engineer of the C., A. & C. R. R. at Akron. In 1887 he was elected County Surveyor and again in 1890, serving six years until the close of 1893. During his terms, Broadway was graded and macadamized to Bedford, and South Woodland and Wooster Road graded and paved with brick 8 feet wide. These undertakings were the begin-

ning of the extensive road-making program for which this county became celebrated.

This service led to his being employed by the highway department at Washington. He then resumed the private practice of land surveying which he continued until his final illness.

He married Addie Ladd, whom he survived. There were five children, Bertha, Harvey S., William, Ruth and Frances; of these William died shortly after his father.

Mr. Brown was a careful, paistaking and competent surveyor of the older school. Among those who were in his office early in their engineering career were Frank R. Lander, Chas. W. Root, Ralph V. Hecker, Chas. S. Brown, Wm. H. Evers, Edwin Hecker, F. F. Cogswell, E. W. Denison, Judson Wells and others whose names could readily be recalled.

He was a member of this Society for a time, but not in recent years. He was, however, well known to most of the older members, who with his more immediate associates cheerfully bear testimony to his memory.

Minutes.

February 6, 1917. Special meeting was called to order at 8:15 by President Ballard; present, about 140 .

President Ballard introduced W. J. Watson, Consulting Engineer, who gave an illustrated talk on "The Evolution of Bridges". Messrs. A. F. Blaser, W. H. Burrage, A. J. Himes and F. H. Neff took part in the discussion.

Adjourned.

C. E. DRAYER, Secretary.

February 13, 1917. Regular meeting called to order by James Ritchie, 8:15 p. m., in the Auditorium at East Technical High School. Present, 200.

The paper of the evening was presented by E. S. Johnson, of the General Electric Company, Schenectady, N. Y., who outlined the considerations leading to the electrification of the C., M. & St. P. Railroad and showed by slides the detail construction of the electric locomotive used. After the lecture we were entertained by an excellent moving picture, "The King of the Rails."

The following proposed revision of the Constitution was presented in due form and ordered passed to letter ballot:

ARTICLE II.

Membership

Section 6. Junior Members.—A Junior Member must be a person under twenty-eight years of age who is a student or practitioner of Engineering, Architecture or Applied Science.

ARTICLE IV

Transfers and Resignations

Section 5. Junior Member to Active Member or Associate Member.—A Junior Member shall be transferred by the Executive Board to Active or Associate Membership if eligible thereto, upon filing an application for such transfer with the Secretary. If upon attaining the age of twenty-eight years and after due notice by the Secretary he fails to make such application, his name shall be dropped from the rolls of the Society.

ARTICLE V

Fees and Dues

Section 1. Fees.—The Entrance Fee shall be as follows:

Active Member	$10.00
Associate Member	10.00
Corresponding Member	10.00
Junior Member	3.00

A Junior Member on promotion to any other grade of membership shall pay an additional fee of $7.00.

No Entrance Fee shall be paid by Honorary Members.

Section 2. Dues; Fiscal Year.—The Annual Dues shall be as follows:

Active Member	$17.00
Associate Member	17.00
Corresponding Member	8.00
Junior Member	8.00

Payable in advance on the first day of June each year. Provided, however, if they shall be paid within thirty days from the date they become due a discount of Two Dollars shall be made from the amounts named.

NOTE: Members may, if they so desire, make payment in two equal semi-annual installments subject to the same pro rata discount if paid in June and December.

Members may be relieved from the payment of all future dues by making an advance payment in cash of Three Hundred Dollars.

The Fiscal Year shall commence on the first day of June.

In presenting this revision, the Chairman of the Finance Committee, Mr. J. H. Stratton, invited inquiries and suggestions bearing on the finances of the Society.

The following resolutions on the life of W. O. Henderer, Past President, was presented by A. J. Himes, Chairman of the special committee appointed by the Executive Board to draft the memorial:

"On Friday, the ninth day of February, the members who happened to be in the society rooms were shocked by the announcement of the sudden death of our former president, Mr. W. O. Henderer.

"Mr. Henderer had been sojourning in Florida during the recent severe weather, enjoying the pleasures of the southern climate. His death was a surprise to all, though it was known that he had suffered considerably of late from injuries received in an automobile accident in December.

"Mr. Henderer was chosen president of The Cleveland Engineering Society in 1913. His administration was marked by great activity on the part of the Society and rapid progress in its development. Mr. Henderer was admired and highly esteemed by a large number of friends and his loss will be felt not alone in the profession but in circles of business and friendship as well. It is, therefore, fitting and with a grateful feeling of remembrance that we offer the following resolution in commemoration of his service to the Society and the misfortune of his untimely end:

"RESOLVED, That in the sudden death of our esteemed fellow member

and former president, Mr. W. O. Henderer, the Society has lost one of its most prominent and distinguished members;

"That this loss is a great misfortune to the Society, to his friends and business associates and will be felt severely in those activities in which he was wont to join;

"That the condolence and good will of the Society are extended freely to the members of his family in their bereavement; and

"That it is now desired to display the honor and esteem which it feels for the memory of the deceased by placing this resolution of the Society upon the minutes of the meeting and forwarding a copy thereof to the family."

The resolution was adopted by a rising vote.

The following resolution, which had been sent to President Wilson, was read:

"WHEREAS the Government of the United States has severed diplomatic relations with the Imperial Government of Germany, therefore

"BE IT RESOLVED by The Cleveland Engineering Society that the action of the President in severing said diplomatic relations and in making preparations for conditions that may arise thereafter meets with the unqualified approval of the Society and that we, as members of the Society and citizens of the United States, pledge our support to the President and to the country in whatever further action may be taken;

"That a copy of this resolution be forwarded to the President, through the courtesy of our fellow townsman, Honorable Newton D. Baker, Secretary of War, and to the Senators from Ohio and the Congressmen from the districts which include Cleveland."

F. W. BALLARD, President,
C. E. DRAYER, Secretary.

Adjourned.

C. E. DRAYER, Secretary.

February 20, 1917. Meeting called to order by Past President Ritchie at 8:15 p. m. Present, 135.

Mr. Ritchie introduced A. D. Williams, Consulting Engineer, who gave an illustrated talk on "Principles of Furnace Design". Messrs. Fred Peiter, R. B. Clapp, R. H. Danforth and R. B. Chillas took part in the discussion.

Adjourned.

C. E. DRAYER, Secretary.

February 27, 1917. Meeting called to order by Secretary Drayer at 8:15. Present, 175.

Mr. Drayer introduced Laurence H. Hart, Assistant Engineer, Lupfer & Remick, Buffalo, N. Y., who gave an illustrated talk on "The New York State Barge Canal". Discussion was participated in by M. A. Stone, W. B. Rawson, E. H. Payne, C. E. Drayer, A. V. Ruggles, H. V. Schiefer, Ernest Hollings, A. W. Ray, F. A. Weaver, Ed. Linders, W. R. Carson, C. J. Kehrhan, A. F. Blaser, C. O. Palmer, H. W. S. Wood and W. M. Ray.

Adjourned.

C. E. DRAYER, Secretary.

February 28, 1917. Special meeting to consider increase in dues called to order by President Ballard at 8:15. Present, 30.

Messrs. J. H. Stratton, E. E. Ranney, David Gaehr, E. S. Carman, E. B. Thomas, Robert Hoffmann, A. J. Himes, H. W. Pierce, J. W. Frazier, W. M. Faber, W. P. Brown, C. C. Chace, discussed the matter under consideration.

Adjourned.

C. E. DRAYER, Secretary.

March 6, 1917. Meeting called to order by E. B. Thomas at 8:15 p. m. Present, 65.

The meeting was under the auspices of the Foreign Engineering Developments Committee for the purpose of presenting a symposium on "Some Aspects of Freight Transportation and Handling in Foreign Countries."

Mr. Thomas introduced F. A. Vaughan, Chairman of the Foreign Engineering Developments Committee, who had "Notes on European Inland Waterways"; A. F. Fahrenwald, who spoke on "Foreign Governmental Trade Policies"; and A. E. Reed, who presented "Freight Handling at Marine Terminals".

Discussion was participated in by Messrs. M. F. Armour, A. H. Bates, C. W. Brown, W. H. Burrage, J. C. Chillas, J. B. Green, C. O. Palmer, H. V. Schiefer and G. E. Tower.

Adjourned.

C. E. DRAYER, Secretary.

March 13, 1917. Regular meeting called to order at 7:45 by President Ballard in the Chamber of Commerce Auditorium. Present, about 550.

The result of the letter ballot on revision of Article 5 of the Constitution was announced: 155 votes for and 57 against. Ed. Lindmueller and E. C. Young acted as tellers.

In accordance with the provision of the Constitution, seven members were elected to the Nominating Committee. A motion was made and carried that the members of the Nominating Committee be nominated and elected one at a time. The following were elected: Monroe Warner, A. F. Blaser, E. E. Kinnison, J. W. Frazier, B. R. Leffler, Ed. Lindmueller and H. T. Simmons.

A report of the Industrial Preparedness Committee, outlining the organization of the Officers' Reserve Corps, was read by the Secretary.

At 8:15, Major P. S. Bond, United States Engineer, Cleveland District, gave an illustrated address on the subject "War".

Adjourned.

C. E. DRAYER, Secretary.

March 20, 1917. Special meeting called to order at 8:15 by E. B. Thomas. Present, about 125.

Mr. Thomas introduced A. E. Morgan, Chief Engineer, The Miami Conservancy District, Dayton, Ohio, who gave an illustrated lecture on "Flood Prevention". Messrs. A. H. Bates, J. C. Beardsley, R. S. Mayer, M. A. Stone, E. B. Thomas, J. H. Tufel and T. B. Williams took part in the discussion.

Adjourned.

C. E. DRAYER, Secretary.

March 27, 1917. Junior Meeting called to order at 8:15 by C. S. Boyd. Present, 25.

Mr. Boyd introduced W. J. Oettinger, who spoke on "What the Engineer Does With His Spare Time"; G. H. Drake, who told "The Way a Man Should Spend His Leisure Time"; and F. R. Higley, who described "The Course of a Projectile in Flight". Discussion was participated in by L. K. Baker, C. S. Boyd, G. F. Collister and H. V. Schiefer.

Adjourned.

C. E. DRAYER, Secretary.

April 3, 1917. Special meeting called to order by W. N. Crafts at 8:20. Present, about 175.

Mr. Crafts introduced C. D. Carlson, Engineer, Industrial Heat Division, the Cleveland Electric Illuminating Company, who gave an illustrated lecture on "Electric Japanning". Messrs. R. S. Mayer, F. W. Thomas, W .N. Crafts, F. D. Davis, Ed. Lindmueller, C. O. Palmer and C. C. Smith took part in the discussion.

Adjourned.

C. E. DRAYER, Secretary.

April 10, 1917. Regular meeting called to order at 8:15 by Prof. R. H. Danforth. Present, about 100.

The following report of the Nominating Committee, placing in nomination officers for the ensuing year, was read:

"We wish to express our appreciation of the valuable services rendered to the Society by our Vice President, Mr. James H. Stratton, who, for personal reasons, would not allow his name to be considered for the Presidency.

"We desire to thank those members of the Society who have aided the Committee by presenting names for consideration. Our greatest difficulty has been, not to find men qualified for the various offices, but to make a choice from the talent available.

"For President, James H. Herron.

"For Vice President, Edgar B. Thomas.

"For directors, George E. Merryweather, Frederick D. Richards, Frank A. Vaughan."

Announcement was made of the appointment by the Board of a special committee consisting of F. A. Scott, W. M. Faber and T. G. Protheroe, to raise a fund of $500 to further military preparedness and enlistment.

Mr. R. D. Burdick told of the need for men of the Ohio Engineers, and urged that our members enlist in that branch of the service.

Mr. Bela Nagy then read a very interesting paper on "The Uses of Hydrated Lime". A lively discussion followed, participated in by W. P. Brown, W. H. Burrage, A. B. Cook, R. H. Danforth, C. E. Drayer, J. C. Feuerstein, W. B. Hanlon, Ed. Linders, Dalton Moomaw, E. J. Newton, R. L. Squier, M. A. Stone and others.

Adjourned.

C. E. DRAYER, Secretary.

April 17, 1917. Special meeting called to order at 8:15 p. m. by J. H. Herron. Present, about 160.

Mr. Herron introduced H. D. Church, Chief Engineer Truck Division, Packard Motor Car Co., Detroit, who gave a paper on "The Effect of the War on Motor Truck Design". Messrs. A. W. Austin (Gramm-Bernstein Co.), R. H. Danforth, R. Fielder (Fifth Avenue Coach Co., New York City), A. A. Gould (Peerless Motor Car Co.), A. M. Lacock (Fifth Avenue Coach Co., New York City), Ed. Lindmueller, John McGeorge, R. S. Mayer, T. A. Mealey (Standard Parts Co.), A. S. Scaife (White Motor Co.), G. W. Smith (White Motor Co.), G. E. Tower, R. H. West and Edward Wotton (Fifth Avenue Coach Co., New York City), took part in the discussion.

Adjourned.

C. E. DRAYER, Secretary.

April 24, 1917. Semi-monthly meeting called to order by A. F. Blaser at 8:10 p. m. Present, about 125.

Mr. Blaser introduced R. W. Parkhurst, who gave a report on the work of the Publicity Committee for the current year.

Mr. Blaser then introduced H. V. Schiefer, who gave an illustrated paper on "The Automatic Skip-Hoist". Discussion was participated in by A. F. Blaser, R. H. Danforth, Ed. Linders and C. O. Palmer.

Adjourned.

C. E. DRAYER, Secretary.

May 1, 1917. Special meeting called to order by G. E. Tower at 8:15 p. m. Present, about 110.

Mr. Tower introduced Prof. C. D Hodgman, who gave an illustrated paper

on "Color and Color Photography". Messrs. A. H. Bates, R. H. Danforth, F. J. MacDonald, John McGeorge, H. V. Schiefer, G. E. Tower, S. T. Wellman and A. D. Williams took part in the discussion.

Adjourned.

C. E. DRAYER, Secretary.

May 8, 1917. Regular meeting called to order at 8:15 by President-elect Herron. Present, about 100.

Reading of the minutes of December 12 and 19, 1916; January 2, 9, 16, 23, 30; February 6, 13, 20, 27, 28; March 6, 13, 20, 27; April 3, 10, 17, 24, and May 1, 1917, was dispensed with.

Mr. Herron introduced C. B. Short, Chief Engineer, Northway Motor Manufacturing Company, Detroit, Mich., who gave an illustrated lecture on "New Developments in Motor Design". Discussion was participated in by Messrs A. H. Bates, Ernest Hollings, J. C. Lincoln, John McGeorge, J. M. Marty, C. S. Pelton and E. W. Weaver.

Adjourned.

C. E. DRAYER, Secretary.

May 15, 1917. Special meeting called to order by Vice President Stratton at 8:15. Present, about 125.

Mr. Stratton introduced T. F. Bailey, President, The Electric Furnace Company of America, Alliance, Ohio, who gave an illustrated lecture on "The Annealing and Heat-Treating of Steel and Melting of Non-Ferrous Metals in the Electric Furnace". Messrs. E. J. Bennett, R. F. Benzinger (Erie Lighting Co., Erie, Pa.), J. J. Bever, E. L. Clarke, T. B. Hyde, E. L. Lannert, J. C. Lincoln, John McGeorge, E. J. Newton, E. J. Noble, C. C. Smith, J. E. Washburn and S. T. Wellman took part in the discussion.

Adjourned.

C. E. DRAYER, Secretary.

May 22, 1917. Semi-monthly meeting called to order by Walter P. Rice at 8:20. Present, about 100.

Mr. Rice introduced C. R. Sturdevant, Educational Director, American Steel & Wire Company, who gave an illustrated lecture on the "Experience of an Iron Atom".

Adjourned.

C. E. DRAYER, Secretary.

May 29, 1917. Meeting called to order by John McGeorge at 8:15. Present, 60.

Mr. McGeorge introduced G. L. McKibben, Gas and Water Engineer, Public Utilities Commission, Columbus, Ohio, who gave a lecture on "Facts Developed by the Natural Gas Survey of Ohio". Discussion was participated in by Messrs. G. E. Doake (N. Y. C. R. R.), J. C. Gillette, F. F. Harman, J. C. Lincoln, Ed. Linders, John McGeorge, C. D. Palmer, C. O. Palmer, H. V. Schiefer, B. Test (1646 Delmont Ave., East Cleveland), and W. H. Thomas.

Adjourned.

C. E. DRAYER, Secretary.

June 5, 1917. Special meeting called to order by President Ballard at 8:15 p. m., in the Chamber of Commerce Auditorium. Present about 350 members and guests.

Mr. Ballard introduced Chester L. Lucas, Associate Editor of "Machinery", who gave a moving picture lecture on "The Manufacture of the 9.2 Howitzer Shell".

Adjourned.

C. E. DRAYER, Secretary.

June 12, 1917. The Thirty-seventh annual dinner of The Cleveland Engineering Society at the Hollenden Hotel will be remember by the 300 members attending for its patriotism, its entertainment and its good fellowship.

The Toastmaster for the evening was our retiring President, Mr. F. W. Ballard, who reviewed the work of the year and at the conclusion of his address conferred honorary membership on two of our distinguished Past Presidents, Mr. Ambrose Swasey and Mr. S. T. Wellman. Mr. Wellman was prevented by illness from attending but sent a very interesting letter which was read by the President. Mr. Swasey was tendered an ovation by the Society and responded in his characteristically happy way.

Our incoming President, Mr. J. H. Herron, upon rising to give his brief talk, was met with a hearty reception by the membership, which forecasts a very successful administration. He announced the chairmen of committees for the coming year.

Announcement was made of the gift to our library by the American Society of Civil Engineers through the Cleveland Association of members of the American Society of Civil Engineers of approximately 22,000 volumes from the library of the national society. For this unusual acquisition we are indebted to our librarian, Mr. G. H. Tinker, and to Mr. W. J. Watson.

The principal address of the evening was given by Mr. G. Douglas Wardrop, editor of Aerial Age, on "War in the Air". Lantern slides and moving pictures were shown bringing to us first hand not only the conditions of the war but an appreciation of the astonishing progress made in aeronautics due to the demands of war.

Music of the evening was furnished by the Y. M. C. A. chorus under the direction of Mr. T. G. Protehroe and stunts by a quartet led by Mr. J. W. Macklin.

Adjourned.

C. E. DRAYER, Secretary.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUG. 24, 1912,

Of the Journal of the Cleveland Engineering Society, published bi-monthly, at Cleveland, O., for April 1, 1917, state of Ohio, county of Cuyahoga. Before me, a Notary Public in and for the State and county aforesaid, personally appeared G. S. Black, who, having been duly sworn according to law, deposes and says that he is the Business Manager of the Journal of The Cleveland Engineering Society, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of Aug. 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit: 1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, The Cleveland Engineering Society, 310 Chamber of Commerce Bldg., Cleveland. Editor, Publication Committee, R. I. Clegg, chairman, 310 Chamber of Commerce Bldg. Managing Editor, None. Business Manager, G. S. Black, 310 Chamber of Commerce Bldg. 2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.) The Cleveland Engineering Society, composed of 1200 members. President, F. W. Ballard, 811 Swetland Bldg., Cleveland, O.; vice president, J. H. Stratton, 7000 Central Avenue, Cleveland, O.; secretary, C. E. Drayer, 512 Columbia Bldg., Cleveland, O.; treasurer, E. E. Ranney, 88 Marloes Avenue, East Cleveland, O. 3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None. 4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him. 5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is. (This information is required from daily publications only.) G. S. Black, Business Manager.

Sworn to and subscribed before me this 29th day of March, 1917.

(Seal) A. J. Miller, Notary Public.

(My commission expires April 26, 1918.)

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Annealing and Heat Treating of Steel and Melting of Non-Ferrous Metals in the Electric Furnace.

By T. F. Bailey*

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Introduction

The development of electric furnaces for the heating operations subsequent to the melting and refining of steel has been attended by the usual slow process of any radically new development; and the types now in operation are the result of the gradual elimination of weak and faulty features, rather than from skill in original design. In the early development, much higher prices were charged for electric current than is now the common rate, and this, in addition to the fact that central stations themselves did not consider electric furnaces commercially feasible, contributed to their slow introduction commercially.

The uncertainty of fuel supply and its greatly increased cost have, within the last year, materially aided the introduction of electric furnaces on a considerable scale; and the central stations, which formerly showed a lack of interest in electric furnace development, have, of late, taken an active interest in their introduction.

The incidental advantages of the present electric furnace are so apparent that even at an equal operating cost for fuel, electricity now has the preference; while in some cases, where the net cost of operation is less with electricity, complete installations of magnitude are being made.

While it is not the intention to discuss in detail all of the purposes for which furnaces of the type considered in this paper are adapted, the following are some of the uses to which they have been put:

Annealing steel castings and car axles.
Heat treating steel castings.
Heat treating shells.
Carbonizing.
Annealing aluminum.
Annealing copper.
Annealing brass.
Melting copper.
Melting brass.
Melting aluminum.
Melting silver.

To these lines will shortly be added:
Soaking pits for steel mills.

Rivet furnaces for structural and bridge shops, and later, when there is a real demand for them, furnaces for heating drop forgings.

As it is the purpose of this paper to deal only with furnaces actually in commercial operation, only such types will be discussed.

General Description

All of the furnaces to be later described are of the resistance type, and have, in the case of rectangular furnaces, two troughs made of car-

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borundum fire sand located one on each side of the furnace, with carbon or graphite electrodes located at each end of each trough, the trough being filled with broken carbon material called "resistor material", thus establishing a connection between the electrodes and completing the electric circuit. The general plan of these furnaces may be likened to a closed box of fire brick in which are two glowers, which may be likened to huge incandescent lamp filaments. The control of the current, and hence the heat, is by means of varying the voltage impressed across the electrodes, this variation being obtained by means of numerous taps on the secondary of the special transformer supplied with each furnace.

Car Type Annealing Furnaces

The first furnace is a car type annealing furnace of 150 K. W. electrical capacity, and a heating capacity of 1000 pounds of steel to a temperature of 1650 degrees in one hour, and a current consumption of 300 K. W. hours per ton of material heated to that temperature. The door of the furnace is a heavy casting faced with fire brick and backed by a filling of loose kieselguhr held in place by a steel plate.

Furnaces of this type are well adapted for handling steel castings, and equally well for large or irregularly shaped forgings, and to the annealing of copper and aluminum, to which use they have already been put.

Continuous Pusher Type Furnaces

When materials are of uniform size, or of such nature that they can be pushed, or placed in containers of uniform size, the continuous furnace is sometimes preferable to the car type annealing furnace.

Two furnaces of 120 K. W. electrical capacity each are now in use carbonizing rifle receivers in one of the large rifle making plants in the East. The parts to be carbonized are placed in the usual pots and are pushed into and out of the furnace by means of pushers.

Another furnace of this type is used for annealing brass and german silver flatware blanks in one of the oldest and best known plated tableware plants in the country. Two of these units in operation at this plant each have a capacity of one ton of brass per hour and an electrical capacity of 200 K. W.

Automatic Heat Treating Furnaces

The heat treatment of steel, as separately characterized from the simple annealing operation, consists of heating above a critical point, characterized as the recalescent point, quenching at that temperature in some cooling medium, such as water or oil, and subsequently reheating to a temperature under the critical point mentioned.

As materials specified to be heat treated are usually placed only in locations where considerable strain is present, more attention has been given to so-called heat-treating operation of steel than in the usual annealing, although both annealing and heat treating are equally important if dependence is to be placed on the effect that can be, and is, expected by either treatment.

For the highest quality of work in heat treating, two furnaces are recommended, each one running with the ruling temperature desired in the material at that particular stage in its treatment, and a quenching bath, or spray, as the case may be, located between the discharge end of the first or heating furnace and the charging end of the second or drawing furnace.

The material is gradually moved forward by a pusher, removed by manipulators and quenched in the tank, later removed and placed in front of the drawing furnace and later, after having passed through the drawing furnace, discharged. One installation consisting of two sets of two furnaces each, are used in the heat treatment of

cast steel draw bar knuckles, and are of 900 K. W. per set; each set has a capacity of 72 tons of steel per day. These particular furnaces, and a similar set of furnaces of 600 K. W. capacity for heat treating large high-explosive shells are automatically controlled by special contracting pyrometers, so that all the manual labor or hand work required is the placing of material on the charging platform of the first furnace of the set.

Equipments of this type, while expensive in first cost, approach very closely the highest point of commercial efficiency, as they not only leave no operation to chance, but reduce the labor items to a minimum. I believe that it may be said of one of these units that hundreds of thousands of pieces have passed through it without a greater variation in temperature than 10 degrees from the stipulated point.

This type of equipment is adaptable where the material to be heated is of uniform section, or can be placed in suitable metal containers, and where extreme accuracy is desired or the labor cost reduced to a minimum. With such an equipment, it is possible to produce in the plant a uniformity in the product in line with the tests of the laboratory.

Melting Furnaces For Brass

The reliability of the type of furnaces described in this paper in annealing and heat treating work, seemed to justify the assumption that, with the necessary modifications as to hearth and shape of furnace, they would work equally well on nonferrous metals, and the first furnace for this purpose was installed three years ago for melting silver in the same plant mentioned previously, in which continuous annealing furnaces are used for annealing brass flatware blanks. This furnace was rectangular in shape and provided with a hole in the top and the necessary cover. The metal is melted in crucibles, the furnace being adapted to hold two of size No. 40. Not only is silver melted, but scrap copper as well. The ruling temperature of the furnace is 2500 degrees Fahr., very hot metal being required, as the castings are small and the molds heavy iron.

As there seems to be no real necessity for the use of a crucible excepting in the melting of precious metals, and their high cost, rapid destruction, and the necessity of handling small quantities of metal when they are used, with attending high labor charge, the tilting hearth type furnace was developed. This type of furnace was first used for aluminum and aluminum alloys, and later the same type with slight modifications in the details was used for pouring brass. This furnace, with a normal rating of 105 K. W. and a melting capacity of 600 pounds per hour, has melted the following materials and superheated to a suitable pouring temperature with an average condition as noted below:

New Red Brass.—85 per cent Cu., 15 per cent tin, 400-pound heats in 1 hour with 90 K. W. H. or 450 K. W. H. per ton.

Scrap Yellow Brass.—72 per cent Cu., 28 per cent zinc, 750-pound heats in 1 hour 10 minutes with 120 K. W. H. or 320 K. W. H. per ton.

Scrap Yellow Brass.—70 per cent Cu., 30 per cent zinc, 800-pound heats in 1 hour 18 minutes with 110 K. W. H. or 275 K. W. H. per ton.

Brass Chips and Borings.—70 per cent Cu., 30 per cent zinc, 700-pound heats in 2 hours 30 minutes with 220 K. W. H. or 720 K. W. H. per ton.

Much lower current consumptions have been made on individual heats, but the above are the averages of several heats of each metal melted.

Of all the electric furnaces of the type described now developed, the tilting type furnace is the one offering the greatest saving in cost over fuel-fired furnaces of any type, whether oil, gas or coke fired, as the metal loss is lower, and the crucible cost is eliminated entirely, while the

labor item is less on account of size and convenience of operation.

The following figures may be safely taken as operating conditions with yellow brass in a shop operating 24 hours per day:

	Per ton
Electricity 400 K. W. H. per ton @ 1c	$4.00
Metal loss 1 per cent zinc @ 10c per pound	2.00
Labor, 1 man per hour per 600 pounds @ 36c per hour	1.20
Renewals and repairs	1.00
Total per ton of melt	$8.20

It is believed that the performance of these brass melting furnaces is such, and the saving over other methods so great, that their introduction will be rapid, even much more so than the annealing and heat treating furnaces described, which are now accepted without question.

Electric furnaces are not a cure-all for all the troubles in the metal industry. They are, however, a much more accurate and precise tool than fuel-fired furnaces, and are the means of eliminating many of the troubles in metal production and manipulation, and will, in the lines for which they are adapted, soon come into as general use for heating as electric motors have for power.

DISCUSSION

S. T. WELLMAN.—It seems to me that one of the best uses for this furnace is the melting of brass and aluminum and metals of that kind, especially those that only require a very low temperature, and the saving in metal, especially in times like these when prices are abnormally high.

J. C. LINCOLN.—What is the atmosphere in these furnaces? Is it oxidizing or can it be made neutral?

T. F. BAILEY.—The atmosphere is normally reducing. In any furnace where the doors are not open almost continuously the atmosphere will run almost purely CO.

J. C. LINCOLN.—Does the CO come from the carbon?

T. F. BAILEY.—Yes. Any air that gets into the furnace is rapidly satisfied by the hot carbon in the resistor trough. The disadvantage of that is that it rapidly eats up the resistor, which is one of the items of cost, amounting in some cases to as much as 20 cents per ton of product, on down to, as is the case in brass melting, to probably a cent a ton of product, brass furnaces being much more tightly closed.

JOHN MCGEORGE.—Mr. Bailey spoke of carbonizing. Was that in relation to case hardening? If so, I would like to hear something of the details of it.

T. F. BAILEY.—That was an installation we made for the New England Westinghouse Company for carbonizing rifle receivers. The furnaces were of 120-kilowatt capacity each—two sets. The heating capacity I believe was 600 pounds an hour. The time, I think, was four hours in the carbonizing, which was a thin case.

JOHN MCGEORGE.—How was the carbonizing done?

T. F. BAILEY.—In round pots, 12 inches in diameter, with a hole in the middle of the pot running vertically. Seven receivers were placed in between the two rings, and the usual cover placed on, there being no difference in process from the usual heating or carbonizing furnace, except in the method of getting the heat in the furnace.

JOHN MCGEORGE.—I have heard the statement that steel heated in the resistance furnace will not warp or twist. Is that true, and if so, why?

T. F. BAILEY.—I do not think there is any difference. I do not think the heat in one furnace is any better than the heat in another, except possibly the atmosphere is a little more favorable.

JOHN MCGEORGE.—The statement I heard was that in the carbon resistance

furnace there was no oxygen admitted, and through the chemical reactions there was no ill effect on the steel by the absorption of gases, particularly of the nitrogen. Is there anything in that?

T. F. Bailey.—I do not think so. I think the warping is due more to the uneven heating than anything else.

John McGeorge.—It ought to be better, then?

T. F. Bailey.—Probably, but with the best type of oil or gas furnace run carefully, there would probably be very little difference in the steel. One advantage in the electric furnace is that it is much easier to control. It will keep in perfectly even condition all the time, and that is one of the advantages of an electric furnace over gas. But so far as having a different effect on the steel, I do not think it does unless it is in the atmosphere of the furnace as it may effect the oxidation of the steel.

J. C. Lincoln.—You said your trough was made of carborundum preparation. Is the temperature high enough to make that conducting?

T. F. Bailey.—Yes, it will probably conduct. Of course as the temperature increases it becomes a much better conductor like all refractory materials. Even fire-brick, at 2800 degrees, becomes a very good conductor. This material would probably have about ten times the resistance of the resistor material itself at the temperatures at which we ordinarily run them.

J. C. Lincoln.—What voltage do you use on the furnace?

T. F. Bailey.—That depends on the length of the core. The furnace described for melting brass would have a voltage of about 65 for a 105-kilowatt furnace. The large furnaces, heat treating draw bar knuckles, have a voltage of about 220 and a wattage of about 600 kilowatts in the high temperature furnace, and about 300 kilowatts in the low temperature furnace.

J. C. Lincoln.—Two-phase current, I suppose?

T. F. Bailey.—In that particular case the three phases are divided into two furnaces, the first or heating furnace taking twice as much heat as the second furnace. There are two phases placed on the first furnace, one on each trough. The second furnace the troughs are run in parallel so as to make the transformers alike.

C. C. Smith.—Was the length of time of the heat taken when it was cold or when it was up to heat?

T. F. Bailey.—When it was up to heat in all cases. We are speaking of brass furnaces now. We find that in cooling and shutting down from five o'clock at night until three in the morning, it takes us four hours to bring the furnace to temperature, getting it to working temperature at seven o'clock. That is with a working temperature of about 2500 degrees. We found a working temperature of 2600 was too high, the metal came down too fast, and it would have a tendency to overheat. On a copper heat that we ran of 1500 pounds we found that at the end of two hours there was a difference between the ruling temperature of the furnace and the bath of less than 100 degrees. There is a peculiar thing about the high temperatures, and that is, the efficiency of transmission of heat by radiation is much greater at the high temperatures than at the low temperatures. While it is necessary on the softer metals having a melting point of say 1200 degrees to carry a difference in temperature of 600 degrees between the bath and the roof, on brass running at 2200 degrees about 2300 to 2350 seems to be amply high for the furnace itself in order to bring the heats down rapidly.

R. F. Benzinger (Erie Lighting Co., Erie, Pa.)—At what power factor does the furnace operate?

T. F. Bailey.—About 98½ per cent.

R. F. Benzinger.—What is the ratio of the current required for melt-

ing to the current required for refining? Does the current not taper off at the refining process?

T. F. BAILEY.—No. You mean in the refining or the final heating of the brass?

R. F. BENZINGER.—I probably mean the final heating of brass.

T. F. BAILEY.—We found in practice it was much better to leave the current on at a flat load and pour the heat when it was ready.

R. F. BENZINGER.—There has been considerable trouble with the roof construction.

T. F. BAILEY.—Not in any furnace we have built. This first furnace running on soft metal runs at about 2000 degrees. This furnace has been in operation since last August, and has not had a new brick in it. It has had two resistor troughs in that time, the last trough having lasted to pour 350,000 pounds of metal.

R. F. BENZINGER.—I note that in your paper in giving the cost of melting a ton of brass, nothing was said regarding the cost of electrodes. What is the average cost of electrodes per ton?

T. F. BAILEY.—I can give you that best from the operation on furnaces at the William A. Rodgers plant, running at the same temperature. They put in a pair of electrodes every seven months, running at 2500 degrees. Those electrodes cost about $8. In the Lumen furnace which I referred to as the first unit at this plant, which has been running since last August, they have put in two sets of electrodes, or an average life of something like three months. Those electrodes cost I believe about $24.00, or about $8.00 a month for electrodes.

R. F. BENZINGER.—What is the approximate cost of a one-ton brass furnace?

T. F. BAILEY.—The furnace with a capacity of 1500 pounds costs approximately $8000.00 with the transformers.

R. F. BENZINGER.—On a basis of ten hours operation, is it feasible to keep the furnace up to temperature, or is it feasible to shut it down?

T. F. BAILEY.—Feasible to shut it down. It will drop in temperature from about 2400 degrees to 1900 degrees in the 14 hours cooling.

R. F. BENZINGER.—And then it will take about how many hours to bring it up to the necessary temperature?

T. F. BAILEY.—About four hours.

R. F. BENZINGER.—Where can a brass furnace be seen in successful operation?

T. F. BAILEY. — Lumen Bearing Company. It is running on brass. The first furnace has been running on Lumen metal. This second furnace on brass and manganese bronze. The next furnace may be seen at the plant of the Baltimore Copper Rolling Mills. That plant will be in operation possibly in two weeks.

R. F. BENZINGER.—When melting brass, would the current consumption be on an average of about 400 kilowatt hours per ton?

T. F. BAILEY.—Yes, running continuously.

R. F. BENZINGER.—That does not include the current required to bring the furnace up to temperature?

T. F. BAILEY.—No. I should say in ordinary factory operations of ten hours per day the total current consumption would be 500 kilowatt hours per ton of melt.

R. F. BENZINGER.—How would the cost of one cent per kilowatt hour compare with coke costing about $8.00 a ton, figuring in the same labor, of course, without considering the metal losses.

T. F. BAILEY.—Without considering the metal loss, I think you would have a saving of upwards of about $6.00 to $10.00 a ton.

R. F. BENZINGER.—In other words, what rate would the central station have to make to get this class of busi-

ness competing with coke at that price?

T. F. BAILEY.—I should judge between two or three cents.

E. L. LEONARD.—In hardening large tools, how rapidly should they be heated.

T. F. BAILEY.—Heat them as slowly as possible, as slow as you can get your men to work them, and as slow as your production will allow you. I do not think any mistake can be made in bringing steel up to its temperature by bringing it up slowly. The slower the better so long as it is under the recalescent point. I do not think it makes very much difference in one furnace or the other in rapidity of heating. It is not a matter of furnaces, it is a matter of how quickly the steel can safely take the heat. We have one case in draw bar knuckles where we use four hours to bring them to temperature. I think we could bring them to temperature quite safely at three, but we wanted to be sure they have the same temperature all the way through.

J. J. BEVER.—I would like to ask Mr. Bailey whether he thinks his furnace would be feasible for annealing a steel roll weighing about 20 tons, about 12 feet in length and 3 feet in diameter, solid metal, and how long he thinks it would take to heat that metal and treat it properly?

T. F. BAILEY.—We had this same question come up about three weeks ago, and as I recall, we recommended the use of a furnace requiring 60 hours at least to bring the roll to temperature. The roll was 4 feet 2 inches in diameter, and I think 10 or 12 feet long.

J. J. BEVER.—How long would you hold it to bring it back, or cool it down?

T. F. BAILEY.—Until you need the roll.

J. J. BEVER.—Do you not think you could cool it too quickly and rupture it internally?

T. F. BAILEY.—That is the great danger. I think that if you could let it cool for a week it would be better. I do not think you can let it cool too slowly.

J. J. BEVER.—Then do not you think if you have a number of rolls to cool that you better get a furnace that will take more than one roll at a time?

T. F. BAILEY.—I suggested to try only one roll. He really wanted a furnace to handle 150 tons of rolls a day, I believe.

J. J. BEVER.—You would want 150 furnaces?

T. F. BAILEY.—No, but we recommended that he get one furnace and try one roll first in order to determine the best practice.

MEMBER.—What is the use of cooling castings or other steel and letting them cool so slowly down to say a black heat? After they have cooled below the lower recalescent temperature there can be no change in the structure, so why not cool very rapidly or as rapidly as you choose after you have passed that recalescent temperature?

T. F. BAILEY.—Do you mean in such sections as rolls?

MEMBER.—Anything at all.

T. F. BAILEY.—I think the thing that limits you there is the danger from cooling strains if you cool too rapidly in large sections. If you are not affected by cooling strains, I do not think it makes any difference except the more rapid the cooling the harder the metal.

MEMBER.—You cannot change the structure after passing the lower recalescent temperature.

T. F. BAILEY.—You may get cooling strains that might be serious.

R. F. BENZINGER.—Is the furnace automatically controlled?

T. F. BAILEY.—It is not, that is the ordinary annealing furnace.

R. F. BENZINGER.—Does it require skilled labor in the operation of the furnace?

T. F. BAILEY.—It does not except for general supervision.

R. F. BENZINGER.—In ordinary foundry practice, one ton or 1500 pound heat was ready to pour and the mold was not ready to receive the hot metal. Is there any trouble experienced in maintaining that?

T. F. BAILEY.—If you are working the furnace fast, the temperature will probably climb 100 or 150 degrees. If you are working the furnace with large heats and working it slower, your metal temperature and your bathing temperature will be more nearly alike, so that there is not the danger of overheating.

R. F. BENZINGER.—In keeping this metal hot, does not that increase the zinc loss?

T. F. BAILEY.—It is bound to, but will not increase it as much as it would in an open-fired furnace or in a crucible.

R. F. BENZINGER.—I have in mind a foundry that is operating in the old crucible style today. Of course, the crucible contains a limited amount of metal, and if they would change to the electrically-operated brass furnace they might not be able to take care of that much metal at a time, until they got more accustomed to working it. Under present conditions the crucibles hold a limited amount of metal, and they can take care of that very rapidly. I do not know what their metal losses are, but I think about three or four per cent. You said the losses would be less than one per cent.

T. F. BAILEY.—That would be the average loss.

R. F. BENZINGER.—That three per cent on a fair sized foundry would be, under present metal conditions, a pretty nice lump of money at the end of the year, I think.

T. F. BAILEY.—So far as the size of furnaces are concerned for small foundry work where you have a great variety of mixtures, I do not think this type of furnace is adaptable. I think it would be necessary, so far as our development is concerned, to recommend to a user of a small quantity of metals to keep using crucibles.

R. F. BENZINGER.—This foundry operates on one class of material practically all the time.

T. F. BAILEY.—That is a different thing then.

R. F. BENZINGER.—Chiefly yellow brass.

T. F. BAILEY.—That can be very rapidly handled in this type of furnace.

R. F. BENZINGER.—Suppose it was necessary to hold this metal a half hour or so, how much would that increase the losses?

T. F. BAILEY.—I cannot give you figures on that. I should judge it would increase, depending upon the temperature above the melting point in good practice, each half hour probably a half of one per cent.

R. F. BENZINGER.—Why could not the furnace be automatically operated and keep the temperature down?

T. F. BAILEY.—The furnaces are too sluggish. You do not get the effect from putting on or turning off the current for 15 minutes. You do not really get the full effect of the current for an hour.

R. F. BENZINGER.—Do the 1500-pound furnaces operate on two-phase or three-phase system, or are they single-phase?

T. F. BAILEY.—All single-phase.

R. F. BENZINGER.—It would not make a very nice load for a central station.

T. F. BAILEY.—The size of 105 kilowatt is so small that no central station will make a complaint on that.

MEMBER.—Is there a current demand for 1250-pound furnaces?

T. F. BAILEY.—Yes, 105 kilowatts.

J. C. LINCOLN.—Is this a power factor you obtained on 25 cycles?

T. F. BAILEY.—25 cycle.

J. C. LINCOLN.—Niagara power?

T. F. BAILEY.—Niagara power. There seems to be very little difference

between 25 and 60 cycle. On the large furnaces the power factor runs between 98 and 99, that is on 60-cycle.

J. C. LINCOLN.—You spoke of having insulating material in one of the furnaces. My understanding was it was some quartz material. Does that fine quartz come from California?

T. F. BAILEY.—Yes. It comes from Lompac. We get it from what is now called The Celite Products Company.

J. C. LINCOLN.—That is necessary in order to get anything like the efficiency that you have in the furnaces?

T. F. BAILEY.—Yes. With an ordinary fire brick lining the losses would be probably two or three times as much. It is necessary from every standpoint to hold the radiation losses down comparatively low.

J. C. LINCOLN.—How thick a lining of this quartz material do you use?

T. F. BAILEY.—Eight inches in the brass furnace, and nine inches in the large annealing furnaces.

J. C. LINCOLN.—Was that material pure enough quartz so that it would stand the temperature required to melt steel without fusing?

T. F. BAILEY.—I think it will soften at about 2800 degrees Fahr.

J. C. LINCOLN.—That is just about the melting point of steel.

T. F. BAILEY.—Yes. There is not very much steel excepting electric steel that is poured much above that. Some electric steel will run 2900 degrees Fahr.

E. L. CLARKE.—Have you ever noticed that the power factor is considerably lower when the furnace is cold?

T. F. BAILEY.—It seems to make no difference. There is a slight variation sometimes in the power factor at one quarter to one-half load.

E. L. CLARKE.—What equipment do you find most satisfactory for measuring temperatures?

T. F. BAILEY.—We have not found any satisfactory equipment. But what we have used for the high temperatures has been the regular platinum couple with a Wilson-Meuler instrument, and for taking the temperatures of the bath a Hoskins portable instrument.

E. J. NOBLE.—Has this type of furnace in small units been applied, or is it possible to apply it, to cast iron?

T. F. BAILEY.—It has not been applied; it is probably possible to apply it. Whether there would be economy as compared to other furnaces, I do not know. Only an actual demonstration would tell. But I think the temperature of cast iron is well within the range, as a ruling temperature of 2600 degrees I think is ample to bring down the iron rapidly. The cost, of course, would be considerably higher than in the cupola.

E. J. NEWTON.—I would like to ask Mr. Bailey if he has any knoweldge of an attempt to adapt electric furnaces to annealing large forgings; by large forgings I mean forgings which might be 30 or 40 feet long. The type with which I am familiar is a furnace with a cross-section of perhaps 4 feet by 4 feet and 50 feet long, fired by gas. The great difficulty is to control the temperature and also to prevent local heating, that is to make the temperature uniform along the bars. There is great danger of heating in spots. It does not seem to be quite in line with the discussion tonight, but I myself do not know whether there has been any study made along that line.

T. F. BAILEY.—There has been no installation of furnaces so far as I know. We have recently made two investigations and two proposals that I think will result in contracts for furnaces for annealing forgings and shafts up to 42 feet long. I see no reason why it will not work quite successfully. It is simply an adaptation of the car type of annealing furnace. We are building a large annealing furnace now for annealing bright striped steel on cars. This will

have a capacity of 150 tons a day, and is 193 feet long. Cars move through the furnace continuously, and the metal must come out as bright as when it goes in.

J. J. BEVER.—How much of a load in weight is there in the furnace at a time?

T. F. BAILEY.—In this particular furnace 450 tons. The material will be piled loose on the cars so that the atmosphere of the furnace will be in contact with it.

J. J. BEVER.—How much weight is there on the car before the descent in the furnace?

T. F. BAILEY.—As I recollect, 15 tons on a car, and the cars are about 12 feet long, a little over a ton per foot. Three-day operation in about 193 feet, say 200 feet, would make about 2¼ tons per foot, for two cars. There are two tracks, so every car would be about 1⅛ tons per foot.

MEMBER.—What is the cost per ton for annealing that kind of material?

T. F. BAILEY.—With current at a cent a kilowatt the cost would be approximately a dollar a ton, the current consumption being a little less than 100 kilowatt-hours per ton.

J. E. WASHBURN.—What are the problems of car construction and tracks or chains, the means for pulling this metal through the furnaces. All these being at red heat, I think the problem would be great.

T. F. BAILEY.—In the annealing or the heat treating furnaces as shown for draw bar knuckles, the material is pushed on a cast iron hearth. The life of that hearth has been from three months as the shortest to 7½ months, the longest run they have so far obtained. The average life has been about five months in the last three years. On the car type furnaces the insulating material is placed directly under the hearth, so that very little heat gets down to the axles. The method of moving the car in and out of the furnace is with a rack and pinion, very much like the old-fashioned saw mill carriage. On the large annealing furnace I just mentioned, for bright strip annealing, they were operated by means of hydraulic rams, one on each end of the line of cars. The ram is designed for a push of 50 tons, with a stroke of about 15 feet.

J. E. WASHBURN.—Do these cars have wheels?

T. F. BAILEY.—All have wheels.

J. E. WASHBURN.—What kind of bearings are they?

T. F. BAILEY.—Railway car type journals.

F. S. BENNETT.—All these furnaces heat by radiation, I suppose?

T. F. BAILEY.—All by radiation, all the same general type.

F. S. BENNETT.—Have you compiled any figures as to the cost of annealing malleable castings?

T. F. BAILEY.—We have not compiled any figures because when we went into it pretty carefully we found it was prohibitive in cost on account of the long soaking period. It would run probably four or five times as much as the present annealing furnace with coal.

J. C. LINCOLN.—You spoke of annealing a bright strip. What device do you use at the end of the furnace to keep the air from striking the bright strip and blackening it?

T. F. BAILEY.—In the first place, we would cool it down so that it will not oxidize. Then we had special cooling hoods, so the material would give up its heat before it got into the air.

J. C. LINCOLN.—The heating part of the furnace is what part of the total length of the furnace?

T. F. BAILEY.—The heating part of the furnace is about 30 feet long.

J. C. LINCOLN.—The two sections are connected together so that they are continuous, leaving the CO reducing gas all the way through?

T. F. BAILEY.—Yes.

JOHN MCGEORGE.—Is it possible to employ the same system in heating

steel for tools or hardening gears, or is it possible to keep the steel bright?

T. F. BAILEY.—It is more difficult on account of the greater number of times the small furnace would be opened. But we are building such a furnace now for the Pierce-Arrow for their gears. I do not know that it is a requirement that they shall be bright as they come out, but they will be substantially so in any case.

JOHN MCGEORGE.—That affects the question I asked some time ago. The point is to stop the oxidation of the steel; and I have seen it very definitely stated, if they could stop the oxidation, in other words, the release of nitrogen, and its consequent absorption by the steel, that you would reduce very considerably the liability to warp. I would like to know the truth of that statement, whether it is the nitrogen that causes the warpage of the steel, especially gears, and what the benefit of the electric heating furnace was that the steel was heated out of contact with oxygen.

T. F. BAILEY.—It would seem to me that if an electric furnace were of any particular value in eliminating nitrogen, it would be in the refining of the steel in the first place. I have never seen or heard of the furnace atmosphere having anything to do with the physical property of the steel, excepting carbonizing action or the reverse as the case may be. I cannot answer your question or give you any further light on it.

JOHN MCGEORGE.—In the heat treament of steel, you spoke of heating the steel up above the recalescent point. By that you mean the lower critical point?

T. F. BAILEY.—Yes.

JOHN MCGEORGE.—Isn't there danger of heating above the upper critical?

T. F. BAILEY.—I should have said the upper critical point. In practice it should go a few degrees above the upper critical point in order to be sure it does go through the range completely.

T. B. HYDE.—Where are the heating elements located in the tilting type of furnace, that is, the brass furnace? How are they arranged in that furnace?

T. F. BAILEY.—Those are arranged above the bath, and are completely circular, being divided into two legs by the electrodes, one being placed directly opposite the other.

T. B. HYDE.—Then what is the objection, or why is it we do not have a three-phase furnace. Is it due to the electric complications in the small unit, or is it due to conductivity of the refractory material?

T. F. BAILEY.—It is due solely to the matter of cost and complications. Instead of $8000 per unit, we would have to get about $10,000.00, and there is no particular advantage in three-phase operation on so small a unit. We are building some larger units, 600 kilowatts, that are three to two phase. We are also building a large furnace for the United States Aluminum Company employing 500 kilowatts, single-phase. Wherever we can make a furnace single-phase, we prefer to do it on account of the cost and simplicity, as long as we do not get amperage above 2000, which we are not likely to do in that size of furnace.

R. F. BENZINGER.—On the larger sized brass furnace which you say might be constructed to operate on two-phase, would that be a direct arc furnace, that is, would the heat be directed directly to the metal or indirectly?

T. F. BAILEY.—Indirectly. We use the same type. Arc furnaces are not well adapted to the melting of any material that volatilizes close to its melting point.

R. F. BENZINGER.—The roof then reflects the heat?

T. F. BAILEY.—In the type of furnace which I have described, substantially all the heat comes from secon-

dary heating reflected from the roof.

R. F. BENZINGER.—Is that what might be called a smothered arc?

T. F. BAILEY.—It is not. The only smothered arcs I have seen in practice were pretty sad affairs. They soon cease to be smothered and burn up the furnace. The great trouble with an arc, in my experience, has been where you have an arc you have a temperature of 7000 degrees, and that would melt any refractory known; it will volatilize carbon at that temperature.

R. F. BENZINGER.—What is the average potential?

T. F. BAILEY.—In the brass furnace described, about 65 to 70 volts, running at full capacity.

The Experiences of an Iron Atom.

By Chas. R. Sturtevant*

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I am one of the smallest things in the universe, and one of the very oldest. The earth itself is younger than I, for I was born and cradled in the seething billows of the sun.

From the time of my nativity, infinite aeons ago, to the present, my career has been filled with thrilling incidents. I have traveled through distances and have survived experiences too great even for your imagination to compass. Within the tiny sphere of my being lie hidden the records of the ultimate structure of all matter and within the minute bodies of such as I are potential forces that would wreck the earth if all were to be liberated at once. In all this world, Mr. Man, you have no servitor so universally useful as I and my kind. Without me you would have no railways, no steam engines, no telegraph or telephone systems. You would still be in the middle ages of civilization.

What I now am, how and whence I came into being, my associates and finally, my life of captivity by man—all go to make up a dramatic story which I hope you will find of unusual interest.

In relating this story, I shall occasionally find it necessary to use numbers of such an order of magnitude as to tax the powers of your imagination. This is because I belong to an order of being strange to you, and live in a very different atmosphere than that to which you are accustomed; so radically different in fact, that you may never hope to experience me directly through any of your five senses, even with the aid of the most powerful or sensitive instruments which you have devised to increase the range and acuteness of those senses. Some of my adventures have been so strange and thrilling that you may doubt my statements, but I cannot tell an untruth for I am part of the reality and verity of the universe.

In Which I Introduce Myself

If you had eyes that were very large and very sensitive, fingers that were absurdly small and delicate, and instruments microscopic in size; and if with these you were to divide a very short piece of small wire made of *pure iron* and were to keep on dividing and sub-dividing and sub-dividing each small piece, you would in time reach a limit of division. The result would ultimately be a piece so small as to make further sub-division impossible. Such a piece of iron would be called an *atom* of iron, and it would exactly duplicate me in all respects. There are countless millions of atoms in this earth such as I, all alike.

The smallest object visible to your eye at a distance of 10 inches measures 1/250 of an inch. It would require about half a million of such beings as I laid side by side to span such an object. The most powerful microscope would need to have its resolving power multiplied several hundred fold before you could see me. Yet I am very real. I vibrate ceaselessly and move about with such exceedingly great activity that in all probability my exact diameter will never be ascertained.

I belong to a group or class of about 92 of so-called chemical "elements". We represent as many different kinds of substances. In this group are found such elements as gold and silver, oxygen and hydrogen, tin and sulphur, all

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differing in their physical properties or attributes. We constitute so many different kinds of unit building bricks out of the permutations and combinations of which all things in the universe are made. All atoms are alike in being indestructible, indivisible, uncreatable, eternal—so far as you are concerned. "All the King's horses and all the King's men" could never create or destroy or divide any one of us.

"Everything in God's universe of world and stars is made of atoms, in quantities x, y or z respectively. Men, mice and mountains, the red belt of Jupiter and the rings of Saturn, one and all are but ever-shifting, ever-varying swarms of atoms. Many kinds of atoms, like myself, bulk large in the world's mass, others lie furtively in the hidden places of the earth and are obtained and isolated only with infinite pains and cost. Thus iridium is four times, thorium nine times, cassium 15 times and very impure radium thousands of times rarer and more costly than gold, while others are so rare that they cannot be bought at all."

I resemble the other kinds of atoms in certain other respects also. Instead of being solid, inert substances, as you may have supposed, we are all complex in structure and intensely active, even though minute in size. There are within my spherical surface perhaps 100,000 or more extremely minute particles revolving with great speed about my positive nucleus in regular miniature and planetary fashion. While they move with different velocities, they have the tremendous average velocity of 90,000 miles per second, or half the speed of light. They are so extremely small and active, that I have never yet been able to determine their exact number or character.

These particles are called "electrons" and they have every indication of being negative charges of electricity. They constitute minute centers of energy. All electrons of different atoms are identical in all respects, and they appear to be minute vortex rings of ether, though this is hypothetical. The electrons are in fact the ultimate structural units out of which all atoms and hence, all substances are constructed. Other atoms differ from me only in having a different number and different arrangement of these unit electrons. All atoms are structural modifications of these entities.

Then again, my being as a whole is extremely active and mobile. I have several motions, varying as I am brought into different environments—such as transitory, reciprocal, oscillatory and what is most effective, vibratory. My motions, or those of the molecule of which I may be a constituent part, are always imparted to the all-pervading and extremely tenuous ether in which everything is submerged.

I set the ether in sympathetic vibratory motion and it transmits my motion to distant bodies. Upon these are produced effects of heat or light or chemical action. The ether receives, transmits and imparts our energies. This can be illustrated by the vibratory motion of the atoms in the sun which are transmitted by the ether to the earth, a distance of 93,000,000 miles. When these transverse ether waves strike the earth they give off light and heat and, when they come in contact with certain substances such as molecules of a living green leaf or a sensitive camera plate, they shake the molecules to pieces causing chemical changes to take place. In fact these ether waves liberate about 150 foot pounds of the sun's energy per second on each square foot of the earth's surface.

When I, in bulk (i. e., as a piece of iron), am heated in a dark place until I begin to emit light rays which are just visible to you as a dull red color, I am at such a time vibrating at the tremendous rate of 392 million million times per second. This rate of vibration rapidly increases as I become

hotter, or as the light grows brighter.

The motions of my constituent electrons are likewise imparted to the ether and produce either electrical, magnetic or radio-active effects on other bodies, the manifestation in each case depending on the character of the motions. I have therefore the power of manifesting my presence to you in these several ways, even though I produce no direct effect on your senses.

Under favorable conditions, the converse of these actions is true; that is, if I am placed in an environment where light or heat or electrical or magnetic energy from external sources is being dissipated, either I as a whole or my electrons will be affected and our motions will be accelerated or retarded.

You see from the foregoing that I am virtually a minute reservoir of intensely concentrated energy, and it is a special exalted form or node of energy called "intrinsic". If you, Mr. Man, can ever find an agency through which I may be destroyed or broken down into simpler parts (i. e., if you ever can by some means dissipate a considerable portion of my electrons), you will have tapped an unlimited source of energy with which you could revolutionize the physical world.

If one gram (15.4 grains) of radium could be instantly and completely broken down or disassociated into its electrons, it would (according to one of your scientists) unlock sufficient power to throw the whole of the British fleet from the Channel to the top of Mt. Blanc.

This excessively active state was imparted to my being at the time of my creation and I have never lost it and probably never shall until the end of all things. This perpetual and strenuous activity at times makes me very tired and I am ever alert for an opportunity to impart some of my activity to other atoms with which I am thrown into intimate contact. But I can do this only when the others contain less energy than I, as for instance when they are at a lower temperature than I am—i. e., if their motions are slower than mine. If they should contain more energy than I, then my rate of motion would be increased and I would be worse off than before.

I have never been weighed. Even your most delicate weighing instruments are altogether too gross for such as I. I do know, however, that I weigh 56 times as much as a hydrogen atom, which is known to be the lightest of all and which is said to have unit atomic weight.

I am naturally a very social creature. In all my career on the earth, I have seldom been alone or by myself, and have always been somewhat particular with whom I associated. For instance, I have never been able to get along with lead. I am especially fond of the element oxygen with which I combine in three different proportions, making as many different so-called iron oxides. I also readily unite with silicon, carbon, phosphorus, sulphur, manganese and a number of others. These close combinations of wedded atoms constitute the so-called molecules—the smallest possible divisions or particles of compound substances.

These unions of myself with different kinds of atoms into molecules are, within certain limits, under your control, Mr. Man.

Each particular combination or chemical compound has a set of physical properties all its own, some of which differ profoundly from mine as iron. Since there are no such things in chemistry as fractional parts of atoms, I am invariably combined with a certain definite number of whole atoms, if with any.

When I do unite with other atoms, the settings must be favorable and the ceremony is the occasion for an exchange among ourselves of one or more electrons, and of a corresponding transformation of energy. Among

other things all our complex motions are altered and heat is evolved. And in order to separate me from any molecule of which I am a constituent part, heat must be supplied from without in a quantity equal to that given off by the initial formation of the same molecule. At the same time other atoms must be brought into intimate contact with us which have a stronger affinity for me or my mates than we possess for each other.

I and the other atoms constituting any molecule are bound together by electrical forces, generally called chemical affinity. Our atoms cannot be broken apart except as these binding forces are overcome by the application of some form of energy from without or by the presentation under favorable circumstances of other and more attractive atoms when new groups or molecules will be formed. These molecular changes are going on continually about you, though you are quite unable to perceive them.

The growth and sustenance of animal and vegetable life as well as all chemical changes in inorganic materials is conditional on such activities in our atomic or molecular world. We are in a state of perpetual, unremitting quiver, and whenever any one of us can give up some of our pent-up energy by forming new combinations, or breaking down old ones, we do so.

Speaking of animal life, I wonder if you know that I constitute a most essential part of the building material required by all mammals to sustain life. Among other things, I perform a very important function in every red blood corpuscle, of which there are millions and millions in your own circulatory system. My presence here makes it possible for the blood to carry oxygen from the lungs to the living cells where it unites with carbon giving off bodily heat and certain vital forces.

There are only three things that you can accomplish with me and my kind. You can move me about from place to place, you can within limits determine whom I am to have for my mates and I am sorry to say you have been able to put me to work. The whole iron and steel business which you have developed with all its wonderful train of consequences, constructive and destructive, is based upon your ability to do these three things with me.

As we iron atoms serve innumerable uses to man wherever he makes his abode on earth, so Providence distributed us to all communities. Of all metals we are by far the most useful to man because of our many useful properties—and we are the most abundant and most accessible. Of all the material in the earth's crust, 4.44 per cent by weight is iron. There are but three elements which exist in greater abundance than I, O = 47.17 per cent, Si = 28 per cent, and Al 7.84 per cent. Gold, silver, copper, platinum and aluminum—all are wanting in the hardness and rigidity which suit the iron family to many of its most important adaptations, not one of these metals could be used for track rails or for building or engineering purposes. Neither would they furnish a tool having the edge and temper of fine cutlery. Save nickel, iron is the most tenacious of all useful metals, and it can readily be welded, or forged, or molded into any desired shape. When compounded with certain other elements and treated in certain fashion, it will respond to almost any requirements as to strength, toughness, hardness or resilience. Without me there could be no electrical instrument or machine for I possess more wonderful magnetic powers than any other metal. I am the undisputed king of metals.

II

My Origin and History

This story would be very incomplete were I not to give you a brief history of my wonderful past. As I look back over my eventful career it seems almost incredible that such

wonderful adventures should have fallen to my lot. In the great volume recording the history of the universe will no doubt be found a chapter giving a full and detailed history of my origin and of my activities. But that volume has not as yet been revealed to man, and until such time as it is no other account can ever hope to be complete or perhaps wholly accurate. But at any rate, such a history would be altogether too long for the purpose we have in view, so this account will be very brief, and, I hope, of interest to you.

My origin antedates the earth's nativity for I was evolved in the sun ages before any of the planetary births, billions of years ago. At the time of my evolution the sun—that relic of the primordial fire-mist and the historian of a mighty past—was not the same sun that shines upon the earth today. It was much larger and hotter than it is now, and it revolved on its axis much more rapidly than it does at present. It was a great globe of incandescent gas, subject to powerful eruptive actions, and it contained an enormous concentration of energy arising from its molecular activity and its high gravitative compression.

In the earliest stages of the sun's history only a few of the lighter elements existed, such as hydrogen, helium and asterium. As the sun dissipated heat and lowered in temperature, other elements came into being by the association or grouping of definite systems of electrons. I was one of the first metals to appear. Associated with me during these early stages of evolutionary atomic development were silica, calcium, manganese and a few others. Whether the electrons out of which all of us were made had existed in our sun or in other suns from the eternity of the past—or whether they themselves had been evolved in the sun before my time—I am unable to say. Neither have I ever been able to ascertain the exact nature of their ultimate structure. An account of their history and nature would supply a knowledge of the very foundation of all science; it would constitute a key which would solve the riddle of the universe.

Thus, through immeasurable periods of time, amid inconceivable scenes of fury and excessive activities of kinetic development, I was evolved in the seething fire mists of the sun. These occult energies of atomic association endowed me with all the wonderful attributes which I still possess and which have actuated me during all my prolonged history. The hand that fashioned my being and first gave me activity also gave me perpetual youth and vigor.

After seeming eternities of existence in the sun, and long after I thought I had become settled in life, there came a period when a wandering star or other celestial body made a distant approach to our sun and caused a great disturbance therein. Its approach was accompanied by a differential gravitational pull which drew forth on the sun's surface immense tidal bulges or cones of sun material on the opposite sides of the sun.

At the same time that the cones were drawn out on the line joining the sun and star, a bolt of inward pressure was brought into play at right angles to them. The joint effect of the protrusion of the cones and the compression at right angles to them was a concentration of the sun's eruptive tendencies into the cones. At the same time the eruptive function was powerfully stimulated. As a result the sun shot out great gas bolts from the quasi-volcanic cones whose mass was much greater and whose velocity was much higher than that of the eruptive prominences which are now shot forth at intervals in a more sporadic way. The sun shot forth gas bolts to the amount of 1/745 of its mass, which was sufficient to form the members of the whole planetary family, including the earth. These

gas bolts were given a transverse momentum by the attraction of the passing star. Thus the planets into which they were later collected received their high endowments of momentum.

One of the bolts of fiery matter (in which I was included) which was shot out from the sun formed into "a nebulous knot which served as a nucleus or crater upon which fell much scattered nebulous matter during later periods. The central portion of the knot, constituting only a minor fraction of the adult earth, was in a dormantly inter-collisional state, while the outer portion was almost inevitably in a dominantly orbital state, the latter circling about the former. The central inter-collisional portion rapidly collapsed into a dense spheroid so far as composed of rock substances. The portion that revolved about this, after the manner of minute satellites, was collected only as the occasional collision of the small satellites drove them from their orbits into the earth nucleus, or else they were driven in by falling bodies from without."—(T. C. Chamberlaind.)

In some such manner the earth was born and endowed with its motions and with its energy. It was under such circumstances that I left the sun and became an essential, though tiny, part of the earth. Of my existence in the earth during its adolescence—when it was passing through fiery stages of youth, during those ages when oceans and continents were being evolved, and on down during those later geologic ages which witnessed the evolution of all vegetable and animal life—I shall not attempt here for lack of time, to give an account though I vividly recall my life in those days so filled with stirring scenes, wild excitement and thrilling adventures, that in comparison my recent experiences have been placid indeed.

During all the earlier ages of the earth's development I was shifted about from place to place by various agencies, sometimes being deep down in the abyss of the earth, and sometimes on the surface or dissolved in its waters.

The static pressure near the earth's center is now about 22,500 tons per square inch, and the center is in a highly-heated and rigid and elastic state. You cannot wonder then that I was most happy to find myself one of the great mass of lucky atoms to be finally thrown to the earth's surface where I would escape such an unpleasant and eternal imprisonment.

As a final result of all the mighty world-making activities we iron atoms have been pretty thoroughly scattered about over the earth, and we are often found in great beds both at the surface and at great depths. It will not be wondered at that we are never found in the pure state (except as meteorites which have fallen to the earth), but that we are always combined with other elements, especially with oxygen. Iron atoms abound universally as constituents in the rocks and minerals of all geologic ages. We are dissolved or held suspended in nearly all waters, and we abound even in the bogs formed during your time.

Our presence is often indicated by black, brown, red or yellowish color, though many times showing no color at all. Red soil so prevalent in some regions—red sandstone, red shale, red brick, like the red rust on the track rail—all indicate our presence as a red oxide of iron. Iron imparts the beautiful tints and shades to many a precious stone or jewel which you prize so highly. The yellow precipitate on the bottom of the stream is the same, plus water in combination—that is, when I am united with oxygen and with water in crystal form my color is yellow like ochre.

To be more specific as to my own career, at a certain time in an early stage of the earth's development, when it was surrounded by an envelope of dense and highly heated poisonous

gases, a great mass of molten rock material, containing about 6 per cent of iron oxide, by a mighty outbreak of the earth's imprisoned forces, was forced to the surface through other masses already formed, and in time it also cooled and solidified into a thin crust of igneous rock. I was included in this mass as a molecule of ferrous oxide (FeO). During subsequent upheavals and torrential rains this rock suffered decay. Most of the iron which it contained was leached out of the rock and went into solution while the remainder was held in suspension. I was carried by this water over some highly heated sedimentary rocks, which gave to the water some of their silicates and carbonates, and other mineral substances. This iron-bearing and mineral-charged water finally came to rest in a distant large open rock basin, and in time—by evaporation and chemical reactions—all the mineral substances were precipitated to the bottom of this basin.

Some of the iron atoms were present as ferrous oxides, some as ferrous silicates, and some as carbonates. In course of time there was concentrated here a large bed of iron ore, mixed with and covered by sediment of various kinds.

During the pre-Cambrian age especially—and to a lesser extent during later ages—percolating waters passing down from above produced changes in the chemical and physical character of the original bed. The vegetable matter decayed and disappeared; a period of high temperature drove out all water of crystallization from the limonites, the original carbonates and siderites were decomposed and their iron was changed to the ferric state (Fe_2O_3). While all these changes were taking place our bed was slowly being covered with a thick layer of earthy material, brought down by freshets in the stream that emptied into this basin.

I do not wish to give you the impression that all iron ore beds were formed in this particular manner. I am only relating in a general way what happened to me and my immediate neighbors. I understand that other large deposits have been produced by other agencies than water. In some places heat was the selective agency; in others chemical or electrochemical action caused the iron ores to segregate into veins or lobes. However, probably nine-tenths of all the ore beds were formed by the action of water which carried it off mechanically or in solution, and re-deposited it in beds.

I remained in this ore bed, as part of a ferric oxide molecule (Fe_2O_3) quite near the earth's surface too, for a very, very long period of time. Trees and ferns grew above me, lived for hundreds of years and then disappeared; seasons came and went for hundreds of thousands of years until I despaired of ever seeing the sunlight again. I had a weary, weary wait in this damp, dark grave, but I lived on.

Ultimately our ore bed was discovered by man, and then began a series of stirring and interesting events for me, which will make a chapter in itself.

III

In Which I am Discovered by Man

For a long time I had been hearing unusual sounds and feeling the jarring of heavy machinery above me, and I knew that something very unusual was happening. The disturbances approached nearer and nearer until suddenly, with no special warning, I found myself being lifted up in a large steel bucket along with all my iron ore neighbors.

This took place in the afternoon of a bright clear day. At first the sunshine blinded me for it had been an immensely long time since I had last seen the sun. When I regained my sight sufficiently to look about, I noticed that we were being lifted and moved about by a large steam shovel. I could see but one man operating this

machine and I noticed that he could apparently make it do anything he wished. This was the first man I had ever seen for man had not yet come into existence when I last saw the light of day. But I was destined to see much more of him and to learn of those truly wonderful intellectual and rational powers with which he alone of all animal life has been endowed. I soon learned that through the possession of these powers, man is given the ability to control and utilize these natural forces and forms of energy and to move and shape materials as he may choose in order the better to serve his ends.

There were a number of steam shovels working near by, and I saw that they together had dug an immense hole in the earth which was very deep and which covered many acres. It was apparently in the midst of a forest for many trees were standing about the edge of the hole.

Well, I was quickly dumped into an ore car standing near the shovel and was soon covered up. For many days thereafter, just how many I do not know, I was kept constantly on the move. I occasionally had an opportunity to look about me, but much of the time I was buried deep in ore. That which I am about to relate concerning my adventures was learned partially from my fellows and partially from conversation between men which I could not help overhearing.

Our car was one of a long train of ore cars, each carrying 50 tons. I was therefore but one of many millions of iron atoms which our car contained. After all the cars had been filled, the train was hauled many miles to an ore dock on the shore of a big body of water. Here the train mounted a high trestle, which was built over shipping wharves, and the ore was dumped into bins holding from five to eight carloads. I remained in one of these large bins a few days, and was then forced down through a chute into the hold of a monster ore vessel. Our vessel was loaded in about 25 minutes with 12,000 tons of ore. Last year (1916) 60,000,000 tons of ore were shipped from this region (Lake Superior) alone.

After several days enroute our boat was finally tied to a dock located on a river front near the plant of a large blast furnace. It required less than two hours to unload our boat. This was accomplished by using huge ore traveling cranes and ore bridges. And here I became one of billions of iron atoms forming a great ore pile while all around were other large bodies of material brought here by train and boat. A vast aggregation collected by man to serve his needs.

In what follows I shall purposely omit all those mechanical details of structures and processes which you can see with your physical eyes, and will confine myself to a description of those actions and details which would be impossible for you to observe. In other words, I will act as an instrument to magnify the powers of your mind's eye just as the microscope reveals new worlds to your physical eye.

IV

In Which I am Converted Into Pig Iron

I remained in this artificial pile of ore for several months. Finally there came a day when I was loaded into a small car along with quantities of one or two other grades of ore, and was drawn to the bottom of an inclined steel track. Here we were first weighed, then dumped into another odd-looking car underneath ours. This container, called a skip car, was hauled by a cable to the top of an inclined track and automatically dumped into a small hopper located in the upper portion of a 90-foot stack of varying diameter. This stack was the central feature of the blast furnace plant, and I noticed that surrounding and adjacent to it was a forest of pipes and small stacks.

The bottom portion of our hopper, shaped like a ball, was soon lowered, and our skip load of ore slid down into a much larger hopper, the bottom of which was already covered by coke which rested on another and larger bell. A skip load of limestone was soon poured in on top of us—then the large bell supporting about half a "charge" was lowered and we slid down into the upper end of a shaft on top of a lot of stock previously introduced. A complete "charge" or "round" of material here consisted, I was told, of ore, coke and limestone in the proportion of two parts by weight of ore to one of coke and one-half of limestone. This material—a total of 2000 tons per day—was handled in such a manner that it was quite evenly arranged in layers in the shaft.

Hot, poisonous gases came rushing up through the stock with a deafening roar, and I did not know what to expect next. As charge after charge was piled in above us we kept descending further and further down the shaft into zones of ever-increasing temperature.

Let me explain here more fully the exact condition I was in with respect to my neighbors and companions, so that you may better understand what is to follow. I was a minute part of a small chunk of ore about the size of an egg. If you were to take this in your hand and examine it closely, you would find it to be made up of a great number of small, loosely adhering grains or crystals, some of which are sand, some of stone—and you will find also a little clay. By far the greater number, however, are minute grains of hematite ore, crystalline in appearance. This chunk of ore might be compared to a mixture of red iron rust and earth materials which could be crushed in the hand like mold. Since I was a constituent part of one of these small grains of ore, let me tell you more in detail of its particular structure because this is outside the range of your powers of observation.

First, as to its chemical nature. Our crystalline grain, though so small that you could scarcely handle it with your fingers, contains many hundreds of thousands of molecules, a great majority of which are alike and contain five atoms—two of iron and three of oxygen, Fe_2O_3. I am a part of one of those molecules and as I have already explained, our molecule is held securely together by mutually attractive electric forces. Of the remaining number of molecules constituting the grain, many are made of iron atoms combined with definite numbers of phosphorus, sulphur, manganese or silicon atoms in various combinations. Some molecules contain no iron at all, and a very few contain atoms of other metals, such as copper, nickel and titanium.

These molecules had combined in a compact though irregular manner, and were held together by cohesive forces. They do not constitute a perfect crystal because of the many kinds of dissimilar molecules present. So you see our little grain of ore (little to you but not to us), is quite complex in both its chemical and physical structure. You must not think that all the ore in the piles was in this condition, for it was not. Some of it looked like solid pieces of red or dark stone, while others were lamellar or stratified in structure, and some of it was in a finely pulverized state. But all of it had much the same chemical structure, and contained about 52 per cent metallic iron.

As soon as the temperature of our piece of ore had been raised to above 212 degrees Fahr., the contained moisture was vaporized and driven off. This action, together with the ever-increasing heat, caused the chunk to partially disintegrate thus permitting the hot ore to be permeated by the penetrating gases. When in descending the shaft we had attained a temperature of about 400 degrees Fahr., I

noticed a weakening of the binding forces holding the molecules of our grain together, and shortly after this a curious adventure befell us.

In passing through the range of temperature from 400 degrees to about 800 degrees Fahr. all of the iron oxide molecules in our vicinity were forcibly attacked from all sides by a multitude of carbon monoxide molecules which were determined to capture and carry away with them all the oxygen atoms from our midst. In spite of our combined resistance, our crystalline grain was completely broken down by the united effects of the ever-increasing temperature and this horde of strange and violent molecules. As a result we lost nearly all—but not quite all—of our oxygen atoms. We lost and the carbon gained oxygen.

When I first realized the loss of my oxygen companions with whom I had been so closely associated for ages and ages, I felt much grieved and very lonely. But as there is no great loss without some small gain, so here, the loss resulted in a little rest, for I soon discovered that my vibratory motion had been very slightly reduced. In other words, I had been afforded an opportunity to impart a little heat as a final result of all the changes that had taken place.

As fast as our iron molecules lost their oxygen atoms, we were left in the condition of a porous mass that looked like a small black sponge. At 760 degrees Fahr. this spongy mass began to take on a deposit of pure fine carbon dust, by which it shortly became entirely covered. Later on, just before we reached the melting temperature, the solid carbon attracted to itself and united with the last oxygen atoms in our midst.

Those active gaseous molecules that brought about the foregoing changes were made up of two atoms, one each of carbon and oxygen (CO) known as "carbon monoxide" gas. This molecule was unstable and unsatisfied. The carbon was craving another oxygen atom. It felt as you would feel were you thrust out into a public street with but one shoe. You could get along with one, but you would be mighty uncomfortable and unhappy until you found another shoe, and you would be willing to pay more for the second than for the first.

The carbon atom gave off 70 per cent more heat when it united with the second oxygen atom making CO_2 (carbon dioxide) than when it united with the first, making carbon monoxide. When these molecules rushed up into our midst, we afforded them their first opportunity of satisfying their strong desire for more oxygen, and hence the reason we lost our oxygen to them. The new gas (CO_2) thus formed joined the main current of gases, rushed up the stack and passed out at the top through the downcomer.

After I had moved down the shaft to a depth of about 20 feet I heard neighboring limestone molecules complain that they were being pulled apart or "disassociated", and sure enough when the temperature reached 1100 degrees Fahr., the heat alone began to separate these molecules into lime or calcium oxide (CaO) and carbon dioxide gas (CO_2), the latter escaping to the top of the stack.

Later on, when we reached the very hottest region in the "bosh" where the temperature was about 3000 degrees Fahr., several other actions simultaneously took place about us. The hot lime here was forced by the converging walls of the bosh into intimate contact with all the other oxide portions of the stock, viz.: The silica and ash (SiO_2), the alumina or clay (Al_2O_3) and a portion of the sulphur. When these three substances were brought into contact at this high temperature with the lime, the four formed a pasty mass which united chemically and fell into the hearth below as a liquid "slag". Any one of the oxides by itself would have required a much higher temperature than 3000 degrees

to melt it. In this mass all of the earthy impurities introduced with me as a part of the charge were collected and reduced to a molten state. Being much lighter than iron, the liquid slag floated on top and was easily drawn off at intervals through a "cinder notch".

While this action was going on, our piece of spongy iron melted and trickled down between the pieces of incandescent coke, and fell through the layer of slag into a pool of molten iron which filled the bottom portion of the hearth.

It was during this final stage of my journey through the stack as part of a liquid drop of iron that I observed the source of that strong current of gas which had been constantly rushing up through the stack. Through the upper rim of the hearth were twelve 6-inch bronze pipes projecting an inch or so through the brick wall into the hearth, and streams of red hot air, in all 37,000 cubic feet per minute, were constantly pouring into the furnace through these openings (tuyeres). As the oxygen portion of this air (21 per cent by volume) came in contact with the white hot and porous coke, it penetrated each piece and united chemically with the carbon thus liberating great quantities of heat. Each atom of oxygen combined ultimately with one of carbon making carbon monoxide gas, this being the active reducing agent that robbed us of our oxygen. I watched the process and saw the coke pieces rapidly shrink and quickly disappear from sight, and I also saw the ash falling into the slag with which it united and of which it became a part.

It was while trickling through the coke, and falling through the slag, that the drop of molten iron—of which I am a constituent part—became contaminated with several other elements. In fact all the drops of iron were affected likewise, and the mass of liquid metal as a whole absorbed by weight about 3.5 per cent of carbon; 1.25 per cent of silicon; 0.09 per cent phosphorus; 0.04 per cent of sulphur; and 1 per cent manganese. This means that in every 100 pounds of molten metal there were 3.5 pounds of pure carbon, 1.25 pounds of pure silicon, and so on. All of the metallic impurities present in the stock went into the iron. These foreign elements all being in solution were thoroughly mixed with the iron and were held in captivity by the iron atoms.

Pure iron, containing nothing but iron atoms like myself, can be produced only by laboratory processes. It has a white lustre and is difficult to melt in any ordinary furnace (2800 degrees Fahr.). It is very tough, malleable and ductile. The presence of 3.5 per cent to 4 per cent carbon changes the physical properties of iron completely, making it very brittle, more fusible and rendering it impossible to forge or weld. The principal product of the blast furnace is known as "pig iron"—commonly called "cast iron". This is the principal raw material for your whole iron industry and is now one of the great staples in the commerce of the world. The foundryman makes from it his cast iron kettle and stoves; the puddler in the past refined it and furnished the village blacksmith with wrought iron bars for chains and horseshoes; and the steelmaker now transforms it into rails or watch springs, fence wire or music wire and a thousand other things.

After I had remained in this hearth for several hours an opening or "iron notch" was made through the lower edge of the wall, and the molten iron was permitted to escape and to flow down a trough into a large ladle mounted on a car or truck, carrying me along as a tiny part. Our ladle when filled was covered over with coke dust to prevent free access of oxygen, and also to prevent the rapid radiation of heat. We were then hauled to a Bessemer steel plant where our ladle was bodily lifted to quite a height and we atoms were poured into

a large barrel-shaped receptacle called a "mixer" which held some 1000 tons of molten metal. We found it nearly full of pig iron. The whole mass was thoroughly mixed and made uniform in composition.

V

In Which I Am Converted Into Bessemer Steel

I noticed that pig iron was often poured in on one side and out on the other side of the mixer. Finally I was caught in one of the outgoing streams and found myself in another ladle full of hot metal. This was drawn to the side of a Bessemer "converter". While waiting here to be weighed I noticed that the converter was a large, hollow, egg-shaped furnace mounted on two trunnions extending from its middle, and that it was lined with red hot brick and had a lot of small holes through the bottom. At the time, it was on its side, and its big open mouth was waiting to receive our charge of 15 tons of molten metal. We were quickly poured through a trough into the converter and then streams of air were forced through the small holes in the bottom. Being at 22 pounds pressure the air came with a rush and a roar. The converter was immediately turned to an upright position and then began an excessively rapid series of molecular generations and dissociations that were full of interest —though the workmen on the outside could not see any of these actions and knew little about the wonderful changes that were taking place in our midst.

I was then uncombined and in a free state and, being liquid, had considerable freedom of motion among my neighbors. Ever since I had lost my oxygen companions in the blast furnace, I was very lonesome and was anxious to find others. But the silicon atoms were even more anxious for oxygen than we iron atoms were, and when the air came rushing up through our midst there was a grand rush and scramble for the oxygen atoms. I quickly united with one, and together we started for the top—the two of us (FeO) being much lighter than the iron. But we had not gone far before my new companion was forcibly wrenched from me by a silicon atom. They formed a stable molecule (SiO_2) which rose to the top of the charge and remained there as part of the slag. Some of the iron atoms were more fortunate than I and succeeded in reaching the top with their oxygen companions where they remained along with the other oxides.

When I united with the oxygen, I gave off a certain amount of heat. When the oxygen was wrenched from me an equal amount of heat was consumed—that is, it disappeared entirely as heat and became latent; it was in fact converted into an equivalent amount of work, just the amount needed to separate me from the oxygen atom. But when the silicon united with the oxygen more heat was liberated than was required to dissociate our molecule, resulting in a total temperature increase.

In three or four minutes practically all the silicon had been oxidized and had gone to the top. Before the last was burned, however, the manganese atoms in the same manner and for similar reasons were beginning to oxidize or burn to MnO molecules, and they too went to the top and mixed with the iron and silicon oxides already there. This thin layer of liquid oxides which formed on the top of the mass constituted the "slag". The silicon oxide or silica (SiO_2) neutralizes the other two oxides, and the three unite chemically. The quantity of the metal present in the converter had been reduced in weight by an amount exactly equal to the combined weight of the silicon, manganese and iron thus burned or oxidized.

Meanwhile the temperature of the mass had risen considerably and when it attained a certain critical degree,

the carbon atoms became very active and manifested an unusual avidity for oxygen. Prior to this time they had seemed rather indifferent. Now they united with all the oxygen present and even robbed me of a second oxygen atom I had managed to capture. Their union with the oxygen differed from that of the others in one respect. The new carbon monoxide molecules formed (CO) were so extremely active in their vibrations, and moved about with such extreme velocity, that they were separated from each other by several hundred diameters which placed each entirely beyond the other's influence or control. They constituted in fact a gas, and they escaped from the converter mouth as such, burning further into CO_2 as soon as they came into contact with the outside oxygen-carrying air, forming a long bluish flame. This gas formed so rapidly that it caused an intense boiling or agitation of the liquid mass, and I feared at one time that we would all be thrown out. But presently a little stream of water vapor was admitted along with the air and large quantities of heat disappeared as such in breaking down or dissociating the water molecules (H_2O) into their constituent gases, hydrogen and oxygen. This quieted the mass. Some of the phosphorus and sulphur were also oxidized during these actions, but as they rose to the surface they received such an unwelcome reception by the neutral slag that they were forced back into the iron where they remained after giving up their oxygen.

This whole oxidizing process required only ten minutes of time. During this period nearly all of the silicon, manganese and carbon had been burned out, and a little iron. But not a single atom had been destroyed or annihilated. There were, however, a large number of iron oxide and carbon monoxide molecules which had not succeeded in gaining the top and were floating about in the mass of "blown" metal, enough were present in fact to make it valueless (hot short) as steel. To overcome this difficulty some crushed ferro-manganese (80 per cent manganese; 14 per cent iron; and 6 per cent carbon) was thrown into the ladle as the metal was being poured. This material quickly melted and the manganese promptly gathered up all the oxygen present and rose to the top as MnO. Coincident with this, enough carbon and manganese were added to the charge (replacing a part of that burned out), to give the composition of steel desired by the steelmaker who controlled this whole process.

During this oxidizing process the carbon had been reduced from 3.5 per cent to 0.09 per cent; the silicon from 1.25 per cent to a mere trace; and the manganese from 1 per cent to 0.45 per cent; and both the phosphorus and sulphur had been very slightly increased. (This is merely illustrative and it must not be supposed that all Bessemer steels have this exact composition.) By oxidizing out a portion of its foreign elements the brittle pig iron had been converted into a Bessemer steel which was very high in tensile strength, quite malleable and ductile and which could be readily forged and welded.

And all these changes were giving me new and increasing economic values which were beginning to make me feel quite vain. While I remained in the ore bed as a part of the earth, I had no more value than so much dirt. The work and cost of digging me up and transporting me to the blast furnace gave me a valuation of $5.50 per ton. As pig iron I was worth $36.00 per ton; as Bessemer steel billets I was worth $65.00 per ton; and every conversion or transportation thereafter increased my utility and my selling price. And during all these changes not a human hand had touched me. Last year there were 39,000,000 tons of ingot steel made in the United States.

The ladle into which I had been

poured along with the rest of the metal was swung around above a train of upright ingot molds, made of heavy cast iron. The liquid metal was run through an opening in the bottom of the ladle into mold after mold until all the metal had been poured or "teemed". Each ingot was about 20 inches square, 60 inches high, slightly tapering towards the top, and weighed about 6000 pounds. As soon as the liquid metal came in contact with the thick cold walls of the mold it rapidly lost heat to the mold and the outer portion solidified. As the outer solidifying shell grew in thickness the rate of cooling of the inner liquid mass rapidly decreased, and this action permitted "segregation" to take place. By this I mean that many of those molecules which contained atoms of silicon, carbon, phosphorus, or sulphur—naturally migrated to the central liquid portion which was the last to solidify or "freeze". This is because impure metallic compounds freeze at a lower temperature than do pure metals. In some manner which I don't clearly understand I became a part of a molecule containing both carbon and manganese atoms, and was one of the last to solidify. We were located in the upper central part of the ingot, just below the "pipe"—which I will now tell you about.

Metals occupy greater space or have greater volume when hot than when cold. Perhaps that is because we atoms and molecules vibrate more rapidly when hot, and require a little more room in consequence. The ingot shrinks as it cools, but since the outside is already solid, the only thing left for it to do is to form a cup-shaped cavity on top where the last bit of molten metal solidifies. This depression or hollow space is called a "pipe", and sometimes it extends well down into the ingot. But with care in pouring having the temperature just right and with the aid of further precautions, it can be held within reasonable limits.

And I must tell you of another thing that happened while the ingot was cooling. While it was changing from the liquid to the solid state the metal formed into regular symmetrical crystals, and these grew in size very rapidly, and they continued to grow, small ones uniting to form large ones, until the temperature fell to about 1300 degrees Fahr., which is known as a critical temperature of steel. Since the interior portion cooled much more slowly than the rest, it contained much larger crystals.

Since each solid which crystallizes has its own characteristic form or structure which it assumes if at all possible, and since these differ in general for the different elements found in steel, there was a fierce struggle among some of the elements in their efforts to dominate the others. The carbon in particular wanted to crystallize as flake graphite, but it could not divorce all of the iron and as a final compromise, all of the carbon present united chemically with just enough of the iron to form iron carbide (Fe_3C) and this substance arranged itself in microscopic sheets separated by thin sheets of nearly pure iron, the complex laminated structure as a whole being called "pearlite". This forms only when the metal cools slowly, and it always forms as the temperature falls through the critical range.

I noticed too that practically all of the phosphorus and sulphur in the crystal of which I was a part were forced by the iron to the boundary plains between crystals, forming an envelope of a weak iron compound about the crystal. This greatly weakened the cohesion between crystals. Had there been an excess of manganese present it would have united with most of the phosphorus and sulphur and the combination would have formed into little globules, thus strengthening the metal by removing the weak material between the crystal boundaries.

I should also mention one other

phenomenon which took place in our ingot. As the molten metal was being teemed into the mold, gases and air were carried down with it some of which, failing to escape, were caught in the metal and formed into "gas pockets". These did no especial harm unless located very near the surface.

In an hour or so after teeming, we were moved to another department where a special crane "stripped" the mold off of our ingot. We were then lifted into a "soaking pit" or furnace, where we remained an hour or more until the ingot had reached a uniform temperature throughout, suitable for "rolling".

From here we were conveyed to and placed upon a roll table which carried us to a pair of heavy rolls where we were sent back and forth between the rolls about 19 times. We were turned and moved about, the soft mass of metal being each time compressed and elongated until our stocky red hot ingot had been changed into a long billet bar having a sectional area of 4 x 4 inches—and still red hot. This rolling crushed and broke up the large crystals into smaller ones thus refining and strengthening the metal, and at the same time it closed up the inner gas pockets.

Our billet bar was moved along to power-driven shears, where it was cut into 42-inch billet lengths—the two defective ends being cut into short lengths and scrapped. Since I was imprisoned in one of these short pieces you will be interested in learning what became of it.

VI

In Which I Become Basic Steel

I remained in a scrap pile for several days—just how many I do not know—until I was loaded into a small steel "charging box" along with other scrap. We were soon moved onto the charging floor in front of an open-hearth furnace. Our box was picked up by the long arm of a charging machine, pushed through one of the open furnace doors and dumped into the hearth on top of some limestone and a quantity of iron ore which had previously been placed there. More scrap was quickly introduced and then nearly an equal amount of pig iron. There were about 80 tons of material all told charged into the furnace.

I noticed that the furnace was rectangular in shape and looked from the outside like a baker's oven. It was about 35 feet long by 15 feet wide inside, lined throughout with red-hot fire brick, except the hearth, which was lined with a basic material which was not acted upon by the slag. The furnace had open port holes at each end which were used alternately for the entrance of hot air and gas, and for the exit of the products of combustion.

When all the furnace doors had been closed an intensely hot flame of burning gas was caused to play over the charge. This soon began to melt the iron. I suspected that I was to pass through another refining process, so I said little but kept my eyes open to the many changes that were rapidly taking place.

As the pig iron began to melt, some of the iron was oxidized from the excess air in the flame, and when it had reached a molten state nearly all the silicon present had burned or oxidized into silica (SiO_2), most of the manganese had burned to manganese oxide (MnO), and some of the carbon to carbon monoxide (CO). This latter, being a gas, passed out of the furnace. The other oxides floated on top as part of the slag. When all of the iron had melted, the limestone had been converted into lime which had risen to the top, making the slag strongly basic in nature. This addition released from the slag a large share of the held iron oxide, permitting it to return to the charge where it gave up its oxygen to the other elements. Since the scrap had already been through at least one re-

fining process, it contained less impurities than the pig iron. When therefore all of the iron and the scrap had melted, the impurities of the pig iron were in consequence greatly diluted.

The slag was now covering the steel and it was difficult for the oxygen of the air to penetrate it and get to the metal underneath. To economize in time large chunks of rich iron ore were thrown into the furnace. These went through the slag into the molten metal, and while they were melting they gave up their oxygen to the phosphorus, to some of the sulphur and to nearly all the remaining carbon and manganese. The oxides of phosphorus and sulphur were held by the basic slag, so long as favorable temperature and slag conditions were maintained.

In this manner, we rid ourselves of much of the so-called impurities in our midst, or of the foreign elements. In each case they were oxidized either from the air playing on top or from the iron ore introduced into the molten metal, and all these oxides automatically rose to the top and floated there as a slag—except carbon which passed out of the furnace as gas. This process required eight hours of time, being much slower than the Bessemer process. Toward the last, the workmen frequently introduced long-handled dippers and took out samples of iron or slag after which they introduced certain materials, or changed the working temperature and in that way controlled the quality of steel made.

As we were being poured out of the furnace into a large ladle, ferro-manganese was added to the charge for the same reasons it was added to the Bessemer ladle, i. e., to remove the last trace of oxygen held in the charge and to add just the right amount of carbon and manganese to give the steel desired properties.

In this manner the materials charged into the furnace were converted into soft basic steel and slag. Since all the foreign elements present in the iron had been reduced to a very low percentage, the steel was correspondingly soft and malleable and ductile, as compared with the Bessemer steel. Yet we retained enough manganese to make it tough and workable. Since pure iron is soft and ductile you will have already observed that the qualities of hardness, toughness and strength so requisite to many grades of steel are obtained by adding very small percentages of these few elements about which we have been talking. Carbon alone when present in quantities greater than 0.3 of 1 per cent imparts to steel the very important added property of being hardened and tempered by heat treatment.

Again I was poured into an ingot mold, reheated in a soaking pit and converted into another billet in a blooming mill. In a few days our billet was taken to a rod mill where it was first heated to bright redness, then rolled down into a long rod ¼-inch in diameter and automatically coiled. This coil was taken to a wire mill and prepared for wire drawing. Certain features of this process will, I trust, be of interest to you.

VII

In Which I Am Converted Into a Telegraph Wire

Our rod while being made in the rod mill became covered with a thick, hard, black oxide scale (Fe_3O_4) which is chemically like pure magnetite iron ore. This had to be removed before the rod could be drawn through a die. While there were several ways in which this could have been done, the most effective was with the agency of sulphuric acid. So we were placed in a weak, hot solution of this acid and allowed to remain for about 15 minutes, during which the scale was removed.

A molecule of sulphuric acid consists of a combination of two atoms of hydrogen, one of sulphur and four

of oxygen (H_2SO_4). When this is placed in a quantity of water, the molecule is partially broken down, i. e., the hydrogen separates by itself and carries a positive charge of electricity. The other atoms (SO_4) remain combined and carry an equal negative charge. In all dilute solutions of mineral acids, similar separations invariably take place, and the more dilute the solution the more complete the separation of the acid molecules.

So when we were placed in the acid cleaning tub, we found it filled with millions and millions of positively charged hydrogen molecules and with an equal number of negatively charged acid radical molecules. The former are the extremely active and powerful agents of all acids. When a piece of iron is introduced into such a solution, certain curious phenomena happen.

The charged hydrogen molecules will cause iron atoms to leave the surface of the iron and pass out into the solution. As each iron atom leaves the iron it takes on the positive charge of electricity from a hydrogen atom, and this action continues as long as there are any hydrogen atoms left to give up positive charges. So fresh acid had to be added to the solution at frequent intervals. Heating the solution accelerates this exchange action. If the iron be covered by a black porous scale the hydrogen will act less readily upon it than it will upon the iron underneath.

As the hydrogen loses its charge it becomes a gas and some will rise to the top and escape as gas and some will be absorbed or "occluded" by the iron. Under favorable circumstances steel will take up and hold sponge-like some 18 volumes of hydrogen gas. The latter enters the steel between the molecules or crystals and condenses on these interior surfaces. This makes the steel brittle (acid brittle) but does not greatly change its tensile strength. The gas forming under the scale helped to loosen it from the rod, causing it to drop to the bottom of the tub.

You will see that the chemical action is really an electrical one. It is caused by the fact that energy has in this exchange an opportunity of degrading itself or of "running down" a little, as it always does when possible. A little heat will be developed by the action and the iron atoms will hold the electrical charge more firmly than it was held by the hydrogen.

If you should take this liquid solution which had exchanged its hydrogen atoms for iron atoms and evaporate the water, the positive iron atoms would combine with the negative acid radical molecules (SO_4) and form iron sulphate ($FeSO_4$).

Since I was buried deep in the interior of the rod I was not affected by these chemical actions.

We were taken out of the acid tub and thoroughly washed to remove all traces of acid, then dipped into a tub of hot lime water. This was put on, I learned, to aid in lubrication. Had any acid remained on the wire surface, the basic lime would have converted the acid into gypsum which has a soapy consistency.

We were next placed in an oven where we remained for several hours at a temperature of about 300 degrees Fahr. This expelled the hydrogen gas from the steel and dried the lime. Our rod was next pointed, then threaded through a die and given three drafts to a No. 12 bright wire. The wire of which I was a part was then annealed, thoroughly cleaned in muriatic acid and washed in water, and drawn through a zinc chloride flux to remove from the wire all traces of oxide. Thence on through a galvanizing pan through a special wiping device. In this manner the wire was galvanized, i. e., it was given a smooth, uniform coating of zinc in order to prevent corrosion or rusting.

In the course of time after much handling and traveling about, our coil of wire was stretched on a pole line

and attached to insulators and was later used as part of a long telegraph line. I shall never forget the sensations which I experienced when the first electrical current flowed through our wire, or my impression caused by the strange phenomena surrounding our wire. I was fortunately located on the surface of the wire where I could observe what was taking place both within and without the wire.

All the electrons in my interior were set into an entirely new and different kind of vibratory motion than they had ever experienced before in my normal unelectrified state. When an electric potential difference or voltage was applied to the ends of our line the negative electrons at the positive end of the line jumped out of the adjacent atoms or molecules leaving them positively electrified. These, in their turn, attracted more negative electrons out of the next layer of neutral atoms beyond and so on back to the negative end of the line until there was a complete bucket brigade formed by the atoms, the buckets being the negative electrons and the foremen being the nearly stationary atoms, which pass negative electricity along all the line.

While this method of current propagation may seem to you like a very complicated action you must remember that it has to do with the motion of the electrons which are extremely small and active, so active in fact that the current of electricity flows through a wire at nearly half the speed of light.

Energy was required to cause this unusual agitation of the electrons, and this was obtained from the generator. This energy was finally dissipated as heat. Thus every time a current was sent through our wire, heat was generated in it, the amount being directly proportional to the square of the current. For some unknown reason due to our atomic structure or arrangement, about eight times as much energy is required to force a given current through our steel wire as would be required to send the same current through a copper wire of similar dimensions—and also eight times as much heat would be developed in our wire.

I was interested in a curious phenomenon which always took place simultaneous with the flowing of a current. Strange to say, all of the ether surrounding our wire was instantly thrown into a circulatory motion about our wire as a center every time an electrical impulse passed through the line. The stronger the electrical current the greater the effect upon the ether surrounding our wire. Every time the current was reversed in direction there would instantly be a reversal in the rotational direction of the ether about the wire, showing plainly that the motion of the ether was dependent both in amount and direction upon the strength of the current flowing through the wire.

Had you, Mr. Man, placed a delicately suspended magnet near the wire in this ether flux, the magnet would have been affected by the ether. In fact, it would have aligned itself in the direction of the flowing ether in such manner that in every case it would enter the south pole of the magnet and leave the north pole. This shows very plainly that a wire carrying a current of electricity possesses magnetic properties to the extent of being surrounded by a magnetic field and that it can be transferred into mechanical work. Furthermore, I observed that every time the current and its resultant magnetic flux were altered either in direction or density the fluctuating magnetic field invariably induced an electric current in every conductor placed within the sphere of changing flux.

The magnetic effect of the current was due to the current itself flowing through the wire as already explained. The electrical pressure in the wire, even though no current were to flow

also had its effect upon the surrounding ether, tending to send out rays of electrostatic flux radially from the center of the wire. Whenever the electric pressure is very high, this effect predominates and causes the so-called corona or luminous effects which have sometimes been observed in a poorly designed high potential transmission line. Both the magnetic and the electrostatic disturbances in the medium surrounding a wire are due to the peculiar nature of the vibrating electrons upon the ether in which they as well as the wire are immersed.

Owing to carelessness in handling, before I was suspended in the air a small flake of spelter located just above me had in some manner been chipped off the wire leaving me exposed to the air.

During the first rain storm a drop of water lodged on this exposed place and a peculiar action set up of which I will tell you. The zinc being a different metal from the iron was electro-positive to the iron, i. e., it was at a higher electrical potential than the iron which means that it would cause an electrical current to flow from the zinc through the water to the iron. And that is what happened. As the water spread over the surface connecting the two metals, the zinc atoms left the exposed zinc surface and went into solution, causing a local current to flow from the zinc to the iron through the water which served as an electrolyte, and back to the zinc through the wire.

As fast as the zinc atoms went into the water, they came into contact with oxygen atoms held in suspension, and were oxidized forming zinc oxide. This in time would be washed away and lost in the earth. This action continued at intervals, whenever water was present, until there was a large exposed surface. Up to this time no action had taken place in the iron itself, for we iron atoms were protected by the "zone of influence" of the zinc. But when the exposed iron surface became so large that the zinc could protect it no longer, a corrosive action set up in the iron itself, which greatly affected me. Let me explain quite minutely how this action came about.

There were two exposed iron crystals differing in their chemical composition. One of them, the one I was in, was strongly electro-positive to the other. During a storm they became connected by water. Now this water, like all waters, had suffered slight decomposition. That is, a few of its molecules had dissociated giving positively charged hydrogen and negatively charged hydroxyl (HO) molecules. These were floating about in the water.

The negatively charged hydroxyl (HO) molecules collected about our positively charged metallic crystal, causing me, an atom of iron, and many others, to go into solution. I carried a positive charge of electricity with me. As I went into solution I neutralized two nearby negatively charged hydroxyl molecules and was united with them to form a ferrous hydroxide molecule—$Fe(OH)_2$. Coincident with this action a positively charged hydrogen atom gave up its charge to the negatively charged crystal, then escaped as a gas, causing a current of electricity to flow through the body of the metal back to the crystal which I left. And a little heat was developed.

Now all live water contains air in solution and when our ferrous hydroxide molecule came into contact with the oxygen of this suspended air we were changed to the ferric state and precipitated as red rust, Fe_2O_3.

To state it briefly, the iron atoms of our crystal were caused to dissolve in the water where they came into contact with oxygen and after passing through several successive intermediate actions finally were precipitated as red rust or pure hematite iron ore. This action continued as long as there were positively charged hydrogen

atoms and oxygen and water. The absence of any one of these elements would have stopped the corrosive action. The presence of acids or salts in the water, or of strains in the iron, or of a more heterogeneous iron crystalline structure, would have accelerated the corrosive action.

And so I was finally changed back into an iron oxide, and as such one day I fell to the ground and became mixed with the earthy material in such a diffused state that I will probably never again become a part of an ore bed, or be permitted to serve any more useful purpose as a metal. Perhaps some day I may be absorbed by a root and taken up by the circulatory system of some plant or tree in which case I will pass through another cycle of changes, only to fall back to earth again as a last resting place.

The Natural Gas Situation in Cleveland During the Winter of 1916-1917.

By Geo. L. McKibben*

Paper Presented May 29, 1917.

Index No. 662.6

In appearing before a body of technical men, one feels at liberty to state facts without fear of misinterpretation.

My department has been busy for six months, engaged in making a survey of the gas situation in Ohio. This called for an investigation of conditions in the neighboring states of West Virginia and Pennsylvania, and a general review of the conditions throughout the country.

Natural gas is an elusive product of nature about which very little is known. The chemist knows its constituent parts, but our knowledge of its origin, its location, the quantity stored in the earth, where stored, etc., is limited.

The producer has no knowledge of the life of his wells, when he finds gas, nor has he any way of increasing his supply except by the uncertain method of drilling more wells.

My survey was intended not only to get information as to present and future production, but to get such facts as to its consumption as would enable the Commission to give organized attention to the matter in the future. A little further along, I will give you the gist of my report on this.

The natural gas business is not on its last legs, but certain localities have become exhausted. As an illustration, a score of years ago, Indiana produced nearly as much gas as Pennsylvania, while today it produces about one-thirtieth as much. Various are the theories accounting for its formation, its locations and the quantity that nature has in store, but they are theories only. The practical results are demonstrated by a combination of three essentials: nerve, money and a string of tools.

I have been interested, in various ways, in the gas business, since 1886, and have seen productive fields become exhausted, and investments become practically valueless by reason of the failure of the supply. Yet, today, it would be fair to say that $800,000,000 is invested in natural gas, in various ways, in our country. It was first used for lighting, then followed its use for cooking and heating, while today in its use for industrials, in your city for instance, it is finding its true ability to expand, and its great usefulness to humanity is demonstrated.

The manner in which it has been sold in the past was a grave economic error encouraging wastefulness, and the sooner the right principles of handling this product are applied, the longer will the supply be available.

The State Commission of West Virginia is now realizing the importance of this product and is contemplating drastic action to conserve its supply, which has materially decreased.

It is hardly safe to estimate the amount of industrial investment dependent on natural gas, but give some thought to this in your own city and the results will astonish you.

It has been said to me that substitutes such as coal, coke or producer gases could take its place. This is only partly true. Either of these products increases the manufacturer's investment in several ways and he finally secures a gas of about 50 per

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cent of the heating value of natural gas.

Much can be said of the natural gas situation, and much has been said, but it is well to remember that the quantity and quality are controlled by nature, and its use and waste are uncontrolled by law or practice.

I know of no state that has any organized method of control of natural gas, and I am confident that all distributors would welcome such legislation as would be fair to both consumer and distributer. I have urgently recommended to our State Commission the necessity of this and I believe they will follow my recommendation.

The U. S. Government has made an exhaustive study of the gas industry and has urged economy and conservation. New fields may be discovered—where I don't know—but I have great faith in the persistency of the "Wild Catter".

It is useless to view the matter from any other than a fair business standpoint. The ravings of the political demagogue will not affect the situation. The gas producer is entitled to a fair deal. I believe it was Spencer who said the American public always tried all the known wrong ways first. We are now at the point where we must take the right way or lose one of our greatest necessities. Both the public and the gas companies are to blame for much of the condition today.

The foregoing remarks are general, but we are more directly interested in the conditions existing in Ohio today and I want to say now, that unless something along the line of my recommendations are followed out, the end of the use of natural gas for industrial purposes in Ohio is in sight. And I might go further and say the same as to all uses. Better service will not be had by criticism of gas companies. There is a common platform upon which the public and the gas companies can stand. Careful investigation has been made of the situation in the state and the results I give you with my recommendations. Under present conditions unless there is a new field discovered, I see no hope of improvement in the supply. While the shortage last winter was unfortunate, Cleveland suffered much less than many other communities. I think a condensed statement of the results of the gas survey will give the full particulars of what was found.

The question of rates for gas has been suggested to me. This is not a proper question for me to discuss here as it is dependent upon local conditions governing investment and supply. But I can say that the cost of gas production is increasing, and the supply, from our source is decreasing. You may apply your own method of arriving at the rate question from those facts. Give and demand fair treatment. That's American.

The use of this question for political and sensational purposes should cease and a calm and businesslike view be had. It is going to take a great outlay of money to keep up the present supply, and even then the element of chance is visible and dominates.

I know of no organization of men who are in such a favorable position to get facts relative to this condition before the people of Ohio as your Association and I suggest that you confer this favor upon the public. By your effort a proper feeling of mutual interest could be brought about and unfair criticism be removed, and its place taken by a spirit of good will and fair dealing. I ask you to give this important industry your consideration.

Foreword

In making a survey of the natural gas conditions throughout the state, the thought uppermost was to devolve some plan of concerted action by the consumer and the gas companies,

which would result in a more satisfactory service.

As the outlook for an increased supply is not flattering and the prospect of increased demand is more than likely, it becomes necessary to take immediate steps to not only conserve gas, but to use every means to stop waste in order that the fullest benefit may be had of the available supply.

For these reasons, the unfortunate situation of last winter is of no further concern, other than it serves as an illustration of what will, in all probability, occur again, should conditions be similar, and gives warning for preparation. And to avoid or reduce the serious effects of another occurrence of last winter's condition, suggestions are made to minimize or avoid the same. It is hoped that every consumer and every distributor will heartily co-operate in securing the required result.

This report, therefore, goes no further into last winter's condition than is necessary, as I find that practical suggestions and preventative measures, well carried out, are of more value than theories presented and filed away.

Investigation not followed by action is of no benefit. It is hoped that such attention will be given the suggestions herein as will be of assistance to the Commission in attaining the object of the survey, namely, conservation of natural gas and a united effort to stop waste.

Report of Natural Gas Survey of Ohio

At intervals during the months of December, 1916, and January and February, 1917, the natural gas supply in many parts of the state was inadequate, and caused great inconvenience to both industrial and private consumers. This condition has prevailed in previous winters and your Commission has wisely decided to make an organized effort to better the situation.

A serious problem was presented to be faced by the Public Utilities Commission, as scores of complaints were coming from cities and towns dependent in whole or in part upon this fuel.

Steps were taken at once to afford such relief as was possible. Investigation was postponed until a more opportune time. Drastic action to conserve the entire supply of gas available for domestic use, while seemingly the thing to do, gave the Commission grave concern. Justice to labor and industries having important contracts to fill, was to be considered. The prosperity of both these interests is vital to the public welfare, and much thought was given as to the best methods to pursue.

The demoralized condition of the coal market at this time was unfortunate indeed, and this situation had to be considered in arriving at conclusions.

Your Commission, under date of December 19, 1916, issued Administrative Order No. 28, calling attention to the fact that, by a clause in their schedules, all natural gas companies could suspend all industrial rates for natural gas, and this order was put into effect in the cities of Cincinnati and Cleveland as an emergency measure. The different communities complaining of a shortage were visited and every effort was made to conserve the supply of gas. At Cleveland, Cincinnati, Columbus and other places, meetings were held with the different interests involved. A statement of the mode of procedure in Cleveland, and the conditions and facts brought out there, will in all essentials, fully explain methods and results in the other cities.

The Chamber of Commerce, city officials and the gas company's representatives were present, with other citizens and a full discussion of the actual conditions was had.

Among the first things developed

were, that in May, 1916, the industrials throughout the state were notified by the different gas companies that, on account of a probable shortage, all industrial rates for gas would be discontinued in November. Another was that many of the industrial operators were seriously handicapped by being utterly unable to secure a substitute fuel. Some few of them had already installed either gas producers or oil burners. These few were fortunate. Many contracts had been made for producer gas and oil burning outfits. But conditions in the manufacturing world were such that these contracts had not been filled, nor could any assurance of their completion be obtained. War orders, at great profit, were first. The coal market to the betterment of which the Utilities Commission was bending every effort, offered the industrials no relief. Thus was the very existence of many important industries threatened. Another feature of great importance developed.

Many homes, heretofore using coal for fuel, on account of being unable to get coal or on account of the exorbitant price of the commodity, were driven to take gas, even while fully cognizant at the time of the existing shortage.

Examination of the gas company's books showed that they were delivering more gas than in the corresponding period of the previous year. Pressures at the compressing stations was as high as safety would permit.

Manufacturers were using gas but paying the domestic rates for the same.

When I asked the President of The East Ohio Gas Company why he sold gas to manufacturers even at the domestic rate, and why he allowed the increase of domestic consumers under the conditions existing he answered that he had no recourse. Being a utility, they could not, under the state law, refuse the service. By the authority of the Commission, he would gladly discontinue. Another reason was that knowing many people could not get coal for home use, he felt that he was doing the humane thing to serve them the best he could. In my presence applicants were frankly told the condition, yet they insisted upon being connected.

The above facts and many more were brought out. All realized that the conditions were deplorable and that relief must be had. I suggested that each industrial plant in Cleveland assist me by conserving gas and advising me how much or what percentage of his usual consumption each would conserve without seriously affecting his labor, at any time I called on him. On account of it being a season when labor most needed employment, and the prices of all foodstuffs and necessaries of life being very high and going higher, serious consideration had to be given to this feature. It was understood at the same time that if conditions warranted, I would order all industrials cut off. This idea was approved by the Chamber of Commerce, city officials, the gas company and all present. The gas company agreed to see that the arrangement was fully carried out.

The final result of our work over the state was that almost every industrial in Ohio that used gas was cut off from its use for the time being. This resulted in a great money loss, yet about all of them seemed to feel that the law of the sea, "women and children first," was applicable to this case, and cheerfully bore their money loss.

It would be unfair to attribute this unfortunate situation entirely to natural gas. The condition of the coal market had much to do with it. Coal was not to be had, except at an unusually high price and a great deal of the time not at all. I made no effort to locate the blame, but state the facts as they were developed by my inspectors after a careful examination of many complaints.

This department was able to afford much relief, yet it became apparent that to minimize a recurrence of another shortage, a complete survey of the natural gas industry in the state was necessary in order that an organized method of control would be available to your Commission when another failure occurred.

By instructions of your Commission I proceeded to make such survey and am confident that the execution of the plan recommended, with coal conditions normal, the situation can be controlled. I do not agree with many who advocate the theory that no gas should be used by industrials. Ohio produces only about 50 per cent of the gas it consumes. Were the production of all its consumption a state matter, the conservation of the commodity by that method might be practicable.

Careful consideration was given in making the survey to all such features as were a part of the natural gas industry and especial attention given to the factors of conservation and waste.

The report is given you for consideration under the following captions:

Historical.
Production Within the State.
Transmission Into the State.
Distribution.
Consumption, Domestic, Industrial.
Waste.
The Coal Situation Today.
Suggestions to Domestic Consumers.
Suggestions to Industrial Consumers.
Suggestions to Gas Companies.
Life of Gas Wells.
Importance of the Industry.
Illustrative—Map.
Necessity for Conservation.
Future Control of Gas Consumption.
Card Index System.

September, 1917

Recommendations to the Commission.

Historical

It is not my intention to give historical data further than is necessary to illustrate present conditions and the importance today of an industry grown from what might be termed an accidental discovery about 1884.

The first production of natural gas by drilling was in the states of Ohio and West Virginia in the early part of the nineteenth century and from that time the growth of the industry has been phenomenal, serving many thousands of people in that state.

The first recorded use of natural gas in Ohio was in 1838 when gas from a water well was used as a fuel by Daniel Foster in Findlay, Hancock County. The first recorded use of a well drilled specifically for natural gas was a well drilled in October, 1873, by Homer McLaughlin, at East Liverpool.

Several of the fields that were very productive in the early history of the industry, which was from 1884 to 1895, have become entirely exhausted. New fields have been developed and drilling on a large scale is constantly being carried on to meet the increased demand for the product. To illustrate, in the month of December, 1897, there was, within the state, 729 wells that had produced gas valued at $1,171,777.00. In 1915, 4331 wells produced gas valued at $17,391,060.00, and this latter statement does not include 1733 shallow wells drilled in Ashtabula, Erie, Huron, Lake, Lorain and Cuyahoga Counties.

In view of the growth of this industry and its importance to our people today, it would seem very proper to give it the attention its prominence in the commercial world demands.

Production

The production of natural gas in Ohio has steadily increased since its discovery within the state. Yet Ohio ranks fourth in production and second

in consumption. It might well be said that drilling of the great Karg well at Findlay, Hancock County, in January, 1886, was the basis of the natural gas industry in Ohio. Practically all the gas produced within the state is used within its boundaries, although a small percentage is piped to adjacent towns in West Virginia, Pennsylvania and Indiana.

It is estimated that the volume of gas produced in Ohio in 1915 amounted to 79,510,032,000 cubic feet, and that its total market value was $17,391,060.00 or an average price (domestic and industrial) of 21.87 cents per thousand cubic feet. An increase of 16 per cent, or 11,239,858,000 cubic feet, over the production for the year 1914.

The value of the gas enterprise has been materially increased by the thriving casing-head gasoline industry carried on in Monroe, Jefferson, Columbiana and Washington Counties.

Statistical data for the year 1916 is not complete, but sufficient information is at hand to warrant the statement that the increase in production and consumption was about the same as that of 1915 over 1914.

Transmission Into the State

Approximately 68,186,364,000 cubic feet of gas was piped into the state during 1915 from the outside fields of West Virginia and Pennsylvania and Indiana. This was valued at $14,729,341.00. The greater part was brought in from West Virginia.

Distribution, Consumption, Domestic, Industrial

During the year of 1915, there was distributed and consumed approximately a volume of 146,724,989,000 cubic feet of gas, valued at $31,900,764.00, at an average price of 21.74 cents (industrial and domestic) per thousand feet to 509 cities and towns which were either wholly or in part supplied with natural gas. Fifty-two per cent of this amount was distributed to 773,548 domestic consumers, showing an average annual consumption of 98,632 cubic feet for each consumer, at an average price of 29.35 cents per 1,000 cubic feet or $28.95 per consumer per year, and the remaining 48 per cent representing 29 per cent of the total value, was distributed to 2499 industrial consumers at an average price of 13.32 cents per thousand.

The increase in domestic consumption over the year previous was seven per cent in volume, eight per cent in market value and 5.4 per cent in number of consumers.

With regard to industrial consumers, the percentage of increase was 4.6 per cent in volume, three per cent in market value and ten per cent in number of consumers.

Waste

In my investigation, consideration was given to waste of gas by all classes of consumers. Little attention was given to the condition of many fire boxes under boilers, places where plumbing was insufficient, fire boxes in stoves and furnaces partly filled with paper and other ash and rubbish accumulations of the warm season.

Carelessless in the manner of burning longer than necessary is another source of waste.

The statement of Samuel S. Wyer that but 22 per cent efficiency is obtained in some heating appliances is no doubt startling, yet it is true, many of them only 35 per cent efficient. When it is shown that 70 per cent efficiency it not only possible, but practical, one can calculate for themselves about what is lost by inefficient appliances.

In a report made to the city of Columbus, Ohio, by Consulting Engineers E. A. Hitchcock and Samuel S. Wyer, among other findings was one showing the result of an examination for waste in four houses (names and addresses given) in the city. The average loss by leakage in these four

houses was in amount $5.71 per annum at the prevailing price for gas.

The United States Government, eminent gas engineers and many other interests have given this subject serious thought and issued many warnings, yet organized effort to suppress waste of natural gas has not been made. It would seem that from a standpoint of economy and conservation, some means of reaching gas consumers and gas companies in such manner as to impress upon them the necessity of being economical should be made.

I feel that the gas distributing companies would do themselves and their consumers a favor by looking after these matters; educating the consumer in the proper and economical use of gas would go far in conservation and serve as a means of co-operation by the company and customer, which would do much toward creating that feeling of mutual interest so valuable to both. There is no doubt but that the waste of gas in the early days of its production and use is an important factor in bringing the gas situation to where it is today. Many of us remember burning gas at a flat rate of 50 cents per month per stove, and we found it more convenient to open the door than to turn down the gas.

The Coal Situation Today

I have made some investigation of the coal situation in order that the fullest information may be available for the guidance of the public. The Wall Street Journal of April 30th, 1917, sounds a warning by stating that the United States Government is in the market for about 3,500,000 tons of coal and that while this is the season for purchase by the Government, it will use more this year than usual. The same issue states that prices are from 130 to 150 per cent higher than one year ago and that many of the large New England consumers are not as yet covered on their coal for this year.

I have interviewed mine operators, among them J. C. McKinley, one of the largest producers in West Virginia, and he states that he only hopes to produce 80 per cent of his mine capacity this year and gives as one reason that the transportation conditions are such that miners cannot be kept busy and this makes labor conditions uncertain, as the men can find permanent employment elsewhere. He stated further that coal was now worth $4.00 f. o. b. the mines.

Consumers of gas, as well as of coal, will do well to make provision now for the coming winter.

Martin B. Daly, President of The East Ohio Gas Company, Cleveland, Ohio, in a letter to Hon. Harry L. Davis, Mayor, under date of April 20th, 1917, very frankly states "we now express the opinion that we have probably delivered the maximum amount of gas to Cleveland which we will ever be able to deliver. Any relief from the conditions of last winter must therefore be had through the co-operation of the consumers by the installation of auxiliary appliances for the use of coal or other fuel during the period of shortage of gas. * * * No consumer can wisely depend on gas alone for the period between November 1st and March 1st. * * * If these precautions are not adopted, temporary inconveniences are inevitable."

The results of my investigations confirm the above statements. Gas producers and gas distributors make no effort to conceal the situation. I have no hope of an improved supply of natural gas for next winter, but I do hope for such publicity as will place the real facts before the public.

The Public Utilities can control the use of gas along proper lines, but it cannot control wanton waste. The gas distributing companies could sell every foot of gas they waste. It is equally true that the consumer pays for every foot of gas that he wastes after it leaves the meter. Waste of gas should be stopped. It is not the

large leak, which is always repaired at once, but the small continuous leak that counts. Every gas company and every consumer should carefully examine their gas pipes before winter arrives.

W. W. Freeman, President of The Union Gas & Electric Company, under date of March 15th, 1917, advises Mayor Puchta, of Cincinnati, that his company will have installed in time for the coming cold weather a producer gas plant of 15,000,000 cubic feet per day of gas. In addition they have under contract an additional supply of 12,000,000 feet daily of natural gas, and that they are constructing additional high pressure gas feeders which will serve to maintain an even distribution of gas over the city.

Since the data on the coal situation above noted was secured, prophecies are made that coal prices will be lowered. It is hoped this is true, yet the facts given above are the conditions today.

In the suggestions made herein for the use of gas, there will be found several that call for the co-operation of the distributor and the consumer. It might well be said here that all interested, whether as producer or consumer, should fully realize that this valuable product is entirely controlled by nature, found only in a limited area, uncertain as to supply and neither quantity nor quality controlled by the producer. For this reason, all should make every effort to conserve and by the distributor becoming acquainted with the consumer and giving instructions as to economical use, and the consumer profiting by this instruction, gas bills will be reduced and another result will be practical conservation. Attention to the following suggestions will not only reduce the gas bills but will result in more satisfactory service to both consumer and the gas company.

Suggestions to Consumers

When you have a gas bill higher than expected, don't complain to the gas company until you test your house piping for leaks. This can be done by turning out all fires and all lights. Then watch the small dial on the meter for at least 15 minutes. If the hands move, there is a leak in the house lines. Remember the hand will not revolve and register unless there is gas passing through the meter.

Watch the color of the gas flames in your stove. All flames should burn with a sharp blue tinge without yellow points.

Don't leave your burner turned on full head with flames burning around the sides of the cooking utensil. You are wasting gas. Turn off the gas the instant you are through cooking.

Treat your heating stoves in like manner. Don't burn your gas until the room gets too hot and then open the doors. Keep a thermometer in the room and regulate your gas to your needs.

Examine your lights often. See if dust has accumulated in the mixer and screen. Clean the pin hole through which the gas enters the mixer. Use care and do not enlarge the hole if the supply is sufficient after cleaning the mixer.

Clean your gas burners and make a careful examination of your gas piping and all appliances for leaks before cold weather begins, and find out if you are one of the many who are wasting gas.

Do not search for a leak with a lighted candle or lamp or match. Should you discover a leak, open doors and windows at once. As an emergency application to stop a leak, use soap and a bandage. Don't fail to have permanent repairs made as quickly as possible.

Don't use a gas stove without a flue connection.

Keep the damper in the stove partially closed, according to the amount of fire in the stove. What little draft natural gas requires must be perfect. See that flue and connection are in good shape.

Don't use rubber tubing to connect a gas stove. If you use it in light connections, be sure and have a shut-off cock located at the gas fixture.

Don't have your stove too near the wall.

Be sure to have a sheet of metal under your stove.

When the gas fire in your stove roars, be sure you are not getting the full benefit of the heat units and that you are wasting gas.

Examine your gas burners, if you notice that the flame is red. See if they are not dirty or clogged with paper ash or other refuse. Remove them, take them apart, boil them using soap and washing soda, then regulate the mixer until the flame is of the proper color. An effective flame for the average gas range burner is blue, four inches high and two ounce pressure.

Consult your gas company or a reliable plumber as to anything you are uncertain about. Remember there are two things the gas company cannot do. They cannot control waste in your house any more than a grocer controls the groceries he has delivered to you, nor can they pump air into the gas mains without danger to their entire system.

Learn to read your meter and do this every time the meter man takes the readings. Many misunderstandings will thus be avoided. Errors are sometimes made by over or under-reading meters and the result shows in the next reading by your gas bill being higher or lower than expected. Keep a record of your own readings.

Keep an emergency supply of other fuel on hand. Gas pressure is, for several reasons, low in extremely cold weather. No one knows a way to prevent this.

Suggestions to Industrial Consumers

Good practice with boilers of proper construction and proportioned to the work.

One pound of coal will evaporate nine pounds of water from and at 212 degrees Fahr.

One pound of oil will evaporate 13 pounds of water from and at 212 degrees Fahr.

One pound of natural gas will evaporate 15 pounds of water from and at 212 degrees Fahr.

One pound of coal is qual to 12 feet of natural gas.

One pound of oil is equal to 17 feet of natural gas.

One cubic foot of natural gas will evaporate 0.75 pound of water.

The amount of gas required in making electricity with steam installation with gas for fuel is 40 cubic feet per kilowatt-hour. With a gas engine the amount of gas required for making electricity is about 18 cubic feet per kilowatt-hour, depending somewhat on the type of engine.

The secret of success in the use of gas burners under boilers is to thoroughly mix the proper amount of air and gas before these factors reach the point of ignition.

Careful attention should be given to the covering of grates. See that openings for fire doors are built up with brick and mortar around the burners.

Have on hand an emergency supply of coal or other fuel to tide over a few days during extreme cold weather and have your equipment in shape to make a change temporarily.

In view of the fact that all furnaces are not alike, instructions that will cover every case cannot be given, but nearly all gas companies have experts who can do this and every industrial consumer should either consult the gas company or some authority in this important matter.

Some causes responsible for failures with natural gas burners:

Leak of gas supply at the burner.

Pipes too small—too many turns.

Pipes clogged by corrosion or other foreign matter.

Burner openings clogged with dirt.

Burner capacity too small for work it does.

Insufficient draft.

Burners not properly installed.

Burners not properly operated.

Suggestions to Gas Companies

Get acquainted with your customers and show them by your interest that you *are* interested.

Don't wait for complaints, but have your people see them occasionally and look over the gas-burning appliances.

Diplomacy does not cost a cent and many complaints would be forestalled if they were postponed until "the gas man called again".

Make such suggestions as will improve the service, if possible, thus demonstrating that your welfare is dependent upon that of the consumer.

Do not confine your acquaintance with the consumer to the interview held monthly at the cashier's window.

Very few of your consumers know anything of the production, cost or nature of your product. When unreasonable complaints are made, do not forget that perhaps you were once as ignorant of the business as they. So educate your consumer and show him that your interest is his. You may make unreasonable complaints yourself about things you know as little about as they do about the gas business.

Do not delay looking after complaints.

It is due to the vast investment in this industry and the nature of the same that both the gas company and the consumer realize the necessity of conserving gas. The life of the gas product will be prolonged and all will profit financially.

Many other suggestions might be made but by attention to the above, in a proper spirit, they will follow.

Life of Gas Wells

It will be of interest here to give the result of a survey by this department of 105 wells in one of Ohio's gas producing districts with a view of ascertaining the average life of a gas well. Comparison of field data secured with the company's record of wells was had, and we found the average life of the 105 wells to be 3.95 years. This emphasizes the necessity of constant drilling and this operation is now being carried out on a large scale at great expense in the proven territory by the various producing companies in Ohio. I believe they are putting forth every effort to maintain their capacity and the best that can be hoped for is the maintenance of the present supply. If this is done my expectations will be fulfilled. New territory may develop in time but at the present prices of material and labor, experimental drilling will be checked. And it is well to say here that while I am advised of some transmission line construction going on this season, the market and labor conditions mentioned above are not such as to encourage any extensive operations of this kind either this year or next.

Importance of the Industry

The magnitude of the natural gas industry in Ohio is fully set forth by the records of the Tax Commission of Ohio for 1916, showing an assessed valuation of more than $114,000,-000.00.

Samuel S. Wyer, Consulting Engineer, Columbus, Ohio, publishes the following interesting information which further illustrates its importance:

"Seventy-three per cent of Ohio's population are dependent on natural gas for their cooking, heating or lighting service. This is estimated on the basis of five people to each domestic consumer and that the population of the state in 1916 was 5,252,000.

"Sixty-nine out of 88 (78 per cent) of the county seats of Ohio have natural gas service.

"Thirty-six per cent of all domestic natural gas used in the United States is consumed in Ohio.

"Thirty-six per cent of all domestic

natural gas consumers in the United States live in Ohio.

"Sixteen per cent of all natural gas wells in the United States are located in Ohio.

"Fourteen per cent of all natural gas land acreage in the United States is located in Ohio."

Illustrative

This department is preparing a large map for the use of the Commission which shows location of transmission lines, cities and towns having distribution systems, location of large industrial consumers, other than those located within the corporate limits of cities and towns and location and area of the now producing territory.

Necessity for Conservation

The Bureau of Mines of the United States Government has made exhaustive investigations on this important matter, as have the various states having gas within their boundaries. All recognize that waste of this great natural product has been shameful and that conservation is necessary if we are to enjoy this great luxury provided by nature for an extended period of years.

The investigation made by this department develops that waste is still going on. Each and every one having to do with this fuel should use every means at hand to stop it.

The consumer who would lose his investment in expensive plumbing, furnaces and appliances, as well as the producer and distributor would each lose vast sums by the failure of supply.

The Public Utilities Commission of Ohio needs the help of each consumer and every distributor and producer to assist in such organized efforts as will reduce to a minimum the inconvenience that has been experienced in the past.

More gas was consumed in Ohio during the months of December, 1916, and January and February, 1917, than any previous year in the same months. This was due not only to weather conditions but also to the coal situation.

While each year's statistics show an increase of consumers and consumption, it is equally true that the cost of production and delivery is increasing and it may be in the near future more a question of getting gas at all than the price of gas.

Future Control of Gas Consumption

A survey of the natural gas industry of the state has been made with a view of organizing the various industrial consumers in such manner that the Commission may control the gas consumption as will best serve the interests of all.

The rapid growth of Ohio cities and the call for extensions of distributing lines is a situation to be faced the coming winter. Unless there is a development of new territory, I can see a call for a large increase of consumption with supply inadequate to meet the demand. It is well to again suggest that an emergency supply of other fuel be laid in while it is possible to do so. The outlook for the coal supply at normal prices is not flattering and it would be wise to make preparation before the cold weather season is due, when coal is certain to be at its maximum price.

It will require the closest attention to suggestions given above to enable the Commission to control gas consumption and the co-operation of all interests should be earnestly sought.

Card Index System

A card index system is being prepared of all consumers, both domestic and industrial, who consumed 100,000 cubic feet of gas or over in the month of January, 1917. This system represents much labor and should be kept up to date or it will become useless.

The gas companies should furnish such information to this department as will enable us to correct our index cards, not later than November 20th, 1917.

These consumers have been classified, each city and town being separately filed under the following classes:

Class I.—Industrial consumers who can use fuel other than gas upon few hours' notice, such as have supply of coal or other fuel on hand for emergency and combination furnaces or boilers where burners are easily interchangeable.

Class II.—All industrials that require at least 24 hours' notice to shut off gas and use other fuel or to close down or to partially change to other fuel.

Class III.—Industrials that cannot use other fuel than gas and will have to close down in emergency.

Class IV.—All domestic consumers, schools, hospitals and all industrials where it is not practical to close down without working hardship and cause financial loss. Glass plants would be included in this class.

The Commission having the classification and address of each consumer can give any instructions by class rating either to the distributing company or to the individual direct, as may seem best.

Little attention has been given heretofore to an industry that supplies about three-fourths of our population with heat, light and fuel for cooking and it seems particularly fitting that at this time of conservation of other things that the important industry affecting so many of our people should receive the attention it deserves. In my opinion the Commission has no more important duty than to take such steps at once as will reduce to a minimum at least, any inconvenience or suffering that may result next winter or even the winters further ahead. Especially at a time when unsettled coal conditions hold no promise of cheap fuel. Every foot of gas available is needed to supply comfort to our homes and to turn the wheels of our great industries, full up with orders for their products for one year ahead.

The above statements are the result of a state-wide investigation. Statistical matter is in part taken from government reports. We know how much gas is consumed and for what purpose. We have our card index system of all consumers over 100,000 cubic feet per month and we know the position each one is in to conserve. Our map will be complete as to location of pipe lines and producing fields. In fact we have as full information as is necessary to assist either the consumer or the distributor.

If we can, by our efforts, bring about a mutual feeling of responsibility and concerted action between these parties, we can say that we are all getting the full benefit of a great gift of nature.

While we have not completed the survey, having some of the smaller cities and towns and the transmission lines to examine yet, I feel that necessity exists for the execution of these suggestions at once. The following information is complete, however, and it is sufficient to warrant submission of this report at this time. Information is complete as to—

Production of gas within the state.

Gas brought into the state from other states.

How much gas consumed for domestic use.

How much gas consumed for industrial use.

Average price of gas, domestic.

Average price of gas, industrial.

General average price, both purposes.

Rate of increase in production.

Rate of increase in consumption.

Rate of consumption by domestic consumer, per annum.

For comparative purposes above is shown in cubic feet, money value and percentages.

In presenting the above report with

its suggestions, I feel it necessary to make the following:

Suggestions and Recommendations to the Commission

First.—That copies of this be furnished to the gas-consuming public, and the different gas-producing and gas-distributing companies at once in order that preparation may be made by both industrial and domestic consumers in time for emergency next winter.

Second.—That a conference be had at once with the gas companies that they may have the opportunity of offering such suggestions as may occur to them for conserving gas and eliminating waste and for any suggestions or opinions on the statements made herein.

Third.—That the different civic bodies of the state be asked to be represented for the same purpose. Many inquiries have been made, either through your Commission or direct to this department as to the policy to be pursued by your Commission next winter, and it is only fair to the manufacturers that they be advised at once. At such conference as I suggest, a free and frank discussion with facts before all, a better understanding could be had and much misunderstanding in the future be avoided. Necessity for co-operation would be clearly set forth. This conference has been mentioned by myself to different civic bodies, gas companies and large consumers, and all have stated their approval and assured me of their hearty co-operation.

Fourth.—At the same or a different date, a conference of the Commissions of Ohio, Pennsylvania and West Virginia be held and the question of stopping waste of natural gas be fully discussed and concerted action be agreed upon. This conference would result in much good to both consumers and producers.

Fifth.—That immediate action be taken in order that no delay be had in carrying out suggestions for next winter. May and June are the months when coal is cheaper, usually, than at any other time. As long a season as possible should be given for preparation.

In submitting my report I am aware that in the execution of the plan suggested by the card sysetm, I am approaching discrimination. Yet, necessity knows no law and in order to serve the largest interest—the homes—a great part of them being helpless, we must, of course, do this.

In securing our information we have been materially assisted by the gas companies who have freely offered their assistance giving us access to their records and assisted us in many ways. The same is true of the manufacturers and all with whom we have had to come in contact. All seemed to see the necessity of something being done.

Concerted action can be had and while it may not be possible to supply all the gas wanted in Ohio, we can demonstrate that proper use is made of all available gas. This will at least stop criticism, some of which may be just and some otherwise.

The complete report of the survey will be made when same is finished.

Color and Color Photography.

By C. D. Hodgman*

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Before taking up the discussion of color photography it is of advantage to consider some of the facts concerning color. The particular points which are of interest in this connection are:

1. Color sensation and specification.
2. The Young-Helmholtz theory of color vision.
3. Sources of color.
4. Methods of color synthesis or color mixing.

We consider light to be a wave motion of the ether which stimulates the optic nerve by way of the retina of the eye, producing a sensation which we designate by the same name—light. The normal eye not only distinguishes light and darkness but may differentiate between one light and another equally bright which, as we commonly express it, is of a different color. The physical characteristic which gives rise to this distinction is a difference in the frequency of the ether disturbances which reach the eye.

Our experience in the study of sound shows that the nature of the sensation produced by a simple tone depends on the frequency and intensity of the vibrations producing it. In an exactly analagous manner the sensation produced when light enters the eye depends on the frequency or wave length and on the intensity of the incident waves. In the above statement it is understood that the wave length is the distance between the crests of two successive disturbances as they exist in the medium and that the frequency is the number of disturbances sent out in one second. These two quantities are reciprocals of each other when the velocity of propagation is constant as is the case for a homogeneous medium for both sound and light. Hence, under these conditions, any function which varies as the frequency will vary inversely as the wave length.

Just as the sensation produced by a complex musical tone depends on the frequencies and intensities of its various components, the sensation produced by light depends on the wave lengths and intensities of the separate vibrations which combine to give the sensation. The eye, however, possesses less power of analysis than the ear. Tones which differ in their composition produce different sensations; very small differences in frequency can be detected, and the audible limits extend from about fifteen to above 10,000 vibrations per second. The limits of the visible wave lengths correspond to only about one octave in musical tones—3900 to 7600 Angström units. The limited power of differentiation possessed by the eye is also shown by the fact that it is possible, by allowing light of three single selected wave lengths to enter the eye simultaneously, to produce a sensation indistinguishable from so-called white light; although white normally consists of a combination of all wave lengths within the limits of those having any visual effect.

Color terminology is not entirely satisfactory—the term white light, for instance, is only relative. For ordinary purposes we may consider daylight as white light. As a standard we may accept the color of a so-called black body heated to 5000 degrees absolute as white; this color will ap-

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pear reddish, however, if compared with daylight. For the description or specification of a color, three properties are considered, namely: hue, luminosity and purity. The first property, hue, is known if the wave length of the predominant light is known and may be directly or indirectly specified by a wave length. The second, luminosity, is merely visual brightness. The third, purity, is used to signify the relative extent to which light of any given hue is mixed with white. The distinction between the first and the last term may be made clear if we consider light of a single wave length, having therefore a definite hue, to be altered by the addition of white light. The hue remains the same, that is the dominant wave length is still the original, but the color which was at first pure is so no longer.

The explanation offered for the phenomena of color vision by the Young-Helmholtz theory involves the fundamental supposition that there are three primary color sensations. Three sets of nerve ends have been suggested giving when excited the sensations red, green and blue-violet respectively. The exact physiological explanation of the three sensations is unimportant, the essential feature being the three distinct sensations giving all other colors when excited together in the proper proportions. It has been indicated that each sensation is excited principally by a definite group of wave lengths, the sensation of red being experienced upon excitation of the retina by the longer visible wave lengths, while the medium and shorter wave lengths produce green and blue sensations respectively. Curves showing the relative sensitiveness of each sensation-producing mechanism to different wave lengths can be determined. It is to be noted that the region of excitation for a given sensation is not sharply defined. The sensation of red, for instance, while principally excited by the longer wave lengths shows a measurable response to all wave lengths which produce any visual effect whatever.

The occasional abnormal condition of the human eye, known as color-blindness, is well accounted for by this theory; the explanation being that one or two of the sensations are partially or wholly missing. Another notable phenomena which seems to support this theory is retinal fatigue. If the retina is strongly excited for some time by light of a given hue, which mainly produces one or two only of the three possible sensations and is then immediately excited by white light it appears as if the mechanism of the sensation or sensations produced had been fatigued since the dominant hue perceived is now that caused by the sensations not previously excited. This may be illustrated in a simple manner by preparing two sheets of paper—one of a bright, saturated color, say magenta; and another, larger, of white. Place a black dot at the center of each sheet and with the two sheets strongly illuminated gaze fixedly at the dot in the center of the magenta sheet for about thirty seconds. The gaze is then to be suddenly transferred to the dot in the center of the white sheet. There would now appear an area of pale green on the white paper similar in size and shape to the magenta sheet. Magenta is produced by the simultaneous sensations of red and blue-violet; the mechanisms producing these having been fatigued, the incidence of white light on the retina gives principally the unfatigued or green sensation.

Probably the most important fact which forms the basis for the three-color theory and one which is the working hypothesis of all present practical methods of color photography is that all known colors can be reproduced by combining, in varying proportions, light of three selected wave lengths which, if viewed separately,

would give the sensations red, green and blue-violet.

The facts cited above, together with various others, seem to show that the Young-Helmholtz theory offers the most practical and convenient explanation of the phenomena of color in connection with its reproduction by photographic processes.

The principal sources of color are of three types: First, color due to the wave length of the original radiation; second, colors by dispersion or interference; and third, colors by selective absorption or selective reflection. The radiations from various sources vary from a few single wave lengths to all possible values between the visual limits with a corresponding range of color. We recognize the differences in the colors of light sources not only in flames charged with the vapor of metallic salts as used in pyrotechnics but also in the various types of artificial illumination.

Dispersion and interference form the basis of methods used to separate the radiations from a light source in such a manner that separate images of the source are formed for each wave length present. Each image will then appear of a color characteristic of the wave length which produced it. The series of images thus formed constitute a spectrum, the colors thus produced being called spectrum colors. These are the familiar "rainbow colors" usually indicated as red, orange, yellow, green, blue, indigo and violet, with the intermediate hues. Certain modifications of these appear when the images are allowed to overlap more or less, but in any one spectrum the colors observed are limited to those named above. Colors produced by the combined effects of groups of wave lengths not contiguous in the spectrum would not appear, the most notable case being the series of colors variously designated as purple, pink or magenta.

Many substances absorb or reflect light independently of its wave length. Such substances will always appear to be the color of the light with which they are illuminated. Many other substances, however, possess a property called selective absorption or reflection by virtue of which they transmit or reflect certain wave lengths, but absorb others. The color of the substance is then the color of the light it transmits or reflects; depending not only upon the characteristics of the substances, but as well upon the light which illuminates it. The varied appearance of colored objects when viewed by daylight and by the various artificial sources of light is a good example. The larger part of the colors in nature are produced by selective reflection or absorption; the natural coloring matters of the animal and vegetable kingdoms, artificial dyes, stains and pigments are all instances of this phenomenon. Colors in nature produced in other ways are less common; the rainbow, halos around the sun or moon, the iridescence of certain insects and of sea shells are some of the more common examples.

As has been suggested, all known colors may be produced by optically adding various proportions of red, green and blue-violet light. There are several methods of accomplishing this addition and we may vary the three primary colors from narrow spectrum lines to portions of the spectrum which combined would include the whole range of visible radiations and without sacrificing to any extent the accuracy of the color reproduction. The most direct method of addition is triple projection in which the three selected colors are projected superposed on a white screen by means of an appropriate system of lenses. Suitable adjustable diaphragms in the projection lenses allow the full range of variations in the relative intensities of the three components. The color wheel, a disk showing variable sectors of the three colors and, when rotated rapidly enough, their combined effect, is an-

other well-known method of synthesis. A third method is the use of very small elements of red, green and blue-violet, each element in itself being too small to be distinguished by the naked eye. The effect when viewed is the sum of the effects of the elements and depends on the relative numbers of each color distributed over the area in question. Addition is also accomplished by transparent mirrors of plate glass, a system having been devised whereby light from three color screens is brought simultaneously into the line of sight.

Quite distinct from these methods of synthesis by addition, synthesis by subtraction still accomplishes the same results. In this we start with white light and subtract from it various proportions of the three primary colors, red, green and blue-violet. This may be done by transparent films which selectively absorb the groups of wave lengths which give the sensations. A screen absorbing only the wave lengths corresponding to the red sensation would appear bluish-green, one absorbing green would be magenta or pink and one absorbing blue would be yellow. The superposition of the three absorbing films gives practically the full range of known colors by proper adjustment of the relative strengths of the absorbing media. With the exception of the color wheel all the above mentioned methods of color synthesis are used in the various processes of color photography.

Three-color photography consists first of an analysis of the colors of objects by means of negatives made on specially selected color sensitive plates and using proper color screens, and second, the synthesis of the color elements to reproduce the original effects.

The main problems involved are:

1. The determination of proper plates of requisite color sensitiveness.

2. The fitting of filters to limit the action on the plates to the proper wave lengths.

3. The choice of reproduction colors.

Upon the accuracy of the solution of these problems depends the possibility of producing successful color photographs. The actual processes also involve a considerable amount of technical detail which is often a serious difficulty in the way of accomplishing the desired results.

The ordinary photographic dry plate, consisting of a sheet of glass coated with an emulsion of silver bromide in gelatine, is sensitive principally to the shorter wave lengths, violet and blue. The yellow and red parts of the spectrum show effects only by tremendously prolonged exposure. Such plates cannot be successfully employed to reproduce images of the green and red sensations. Fortunately the addition of minute quantities of certain organic coloring matters to the emulsion increases the sensitiveness in various parts of the spectrum and among the large number of plates now on the market thus color sensitized one may choose such as are suitable. An alternative method is to bathe the ordinary blue-sensitive plate in weak solutions of the proper dyes, the results being as good as with commercially sensitized plates. The process, however, forms a worthy research problem in itself. In whatever way the plates are procured final judgment as to their suitability must be made from photographs of the daylight spectrum taken upon them. The same method is necessary in testing filters for use with the plates.

Filters may be used in front of, behind or between the components of the lens or close in front of the plate. Dry sheets of stained gelatine may be used in front of the plate supported on thin glass or on the plate itself. When used near the lens the outer surfaces of the filter must be plane parallel or very nearly so in order to avoid distortion of the image.

The coloring matter may be in solution in cells or in sheets of gelatine. The important element in the making and fitting of filters is the choice of stains and may well be the subject of extended experiments. A dry filter of small size to be used in front of the lens offers the greatest advantages for experimental work. It may consist of two pieces of thin selected mirror plate each of which bears a coating of properly stained gelatine, the two coated surfaces being cemented together with balsam. The questions to be answered are—what wave lengths should be included for each sensation, whether or not the action should overlap and to what extent. In general, narrow filters, that is, filters passing only narrow portions of the representative red, green and blue-violet parts of the spectrum, appear to give more brilliant results but perhaps a less accurate reproduction of color. The wider filters produce softer photographs and seem to give a more strictly natural rendering. The theoretically correct combination of plate and filter would be that which would give for any part of the spectrum an opacity of silver deposit on the three negatives proportional to the stimulus given to the three color perceiving elements of the eye by the same wave length.

The exposure of the three plates may be made successively in a single camera or all at once in a camera especially constructed to give three images from a single lens. Even in the latter case an exposure several times the normal is required. The three negatives thus obtained form a record of the magnitudes of the red, green and blue-violet sensations to be obtained from the various parts of the object photographed; in other words, a color analysis has been made.

There are various means of performing the synthesis so as to obtain positives in color. The method of triple projection uses black and white positives, made in exactly the same manner as are lantern slides, one from each of the three negatives. They are projected simultaneously through red, green and blue-violet light filters in such a way that the images are exactly superposed. Although excellent results have been obtained the scheme requires a special projection lantern and positives of this sort can be used otherwise only in an arrangement of transparent mirrors which is not wholly satisfactory.

Another method is to make three positives in gelatine on celluloid or other transparent support, by the bichromate process. This is similar to the familiar carbon process of making monochrome prints except that the carbon or other pigment in the gelatine is replaced by silver bromide. This serves as a guide in printing but may be dissolved by a solution of sodium thiosulphate ("hypo") leaving a picture in clear gelatine which may be stained by immersion in a dye solution. The three positives are each colored with a dye which will absorb the light which produces the sensation which it represents. The positive from the red sensation negative is stained greenish blue; that from the green sensation negative, pink, and that from the blue sensation negative, yellow. These three positives, when superimposed, form a transparency in the natural colors of the object. A modification of this method affords very good positives in color on a paper support. When made as transparencies they may be projected by any ordinary lantern requiring to be rather well illuminated by a white light. Several successful methods involving these principles have been worked out and put upon the market under various trade names.

Another type of process, different in many ways but still based on three-color analysis, is called the screen plate process. One plate is used in place of three. The sensitive film of silver bromide, properly balanced as to color sensitiveness, is exposed

directly behind and in contact with a screen the full size of the plate and consisting of very small elements of red, green and blue-violet. These divisions may be lines, squares, hexagons or of irregular shape, but must be small enough to be invisible individually and the proportions of the three colors to each other such as to give a neutral light gray effect when viewed directly. When well illuminated and observed in contrast with other colors it will appear white.

The Autochrome is one of the well-known screen plates and will serve as a good example of its kind. A glass plate is coated with an adhesive and starch grains which have been dyed separately red, green and blue-violet and mixed so as to appear a neutral gray, are spread upon this plate in a single layer. The spaces between the grains are filled with an opaque substance. The starch grains are protected by an impermeable varnish and a very thin color sensitive emulsion laid upon it. The plate may be exposed in an ordinary camera, the uncoated surface toward the lens, the screen of colored starch grains coming between the lens and the sensitive emulsion. By a simple chemical process a positive is produced directly. We have here a transparency of three parts, a positive in red starch grains, one in green and one in blue. These three coexist on the same plate, their effects are added and the original colors reproduced. The finished positive may be used as a lantern slide with sufficient illumination.

Other screen plate processes differ in details. In some cases the color screen is separate, a plate carrying the sensitive emulsion being exposed behind and in contact with it. This plate is then developed as a negative and positives made from it are bound up with a screen similar to the original and upon proper adjusting the colors are reproduced.

Interesting and valuable modifications of existing methods are constantly coming to notice and the art of color photography, which was, not so very long ago, confined to the laboratory of the scientific expert, is now sufficiently simplified to be undertaken by the amateur and by reason of the improvement in results as well as convenience is taking a more important place in science and art.

DISCUSSION

MEMBER.—What is the reason the kinemacolor is not in use at the present time?

C. D. HODGMAN.—That process is, as indicated before, a sort of compromise. There are only two colors involved in it, and it is impossible to reproduce well any of the blues or blue-violets. As a matter of fact, blue-violet is a color which occurs infrequently in nature. The method is, of course, rather costly, and I think was a little disappointing. There are other methods actually in use now, perhaps on an experimental scale, involving the use of the three colors, which it is hoped will give a much better rendition. The Kinemacolor is fairly good, but I think the real reason why it is not more in use is that the results do not quite pay the additional cost.

MEMBER.—Can you describe the Ives triplicate?

C. D. HODGMAN.—You refer to the last one?

MEMBER.—Yes, sir.

C. D. HODGMAN.—I have not used the Hess - Ives process myself. It is the same as the process I have described in the making of the negatives, except the details by which they are exposed. They are exposed in the camera in such a way that one of the plates is exposed in a horizontal position and the image is gotten by a mirror similar to the scheme which I have used. The other two plates are exposed face to face, and on the back of one of these plates, or between

the two, is a thin film which serves as a filter for the second one. Of course, these two films are very close together, and the same image acts on both. These plates are furnished in packs, and one of them falls down into place while the other two stand up; then the mirror is put into position so that one exposure in this particular camera serves for the whole thing. They also have a method which I have not studied particularly, but which is said by some to be fairly successful, of making prints upon paper by a carbon process. There is probably still something to be looked for in that line. Prints can be made in the same way that we have made transparencies by the gelatine process.

Member.—Isn't that used in an ordinary camera?

C. D. Hodgman.—I think the process that he has recently patented, the one that I referred to, could not be used in an ordinary camera.

Member.—They have lately tried out and improved that so that the plates can be used in any camera. That is the latest thing. A year ago they had the camera you describe. I have with me some photographs made by that camera a year ago.

Member.—Do the autochrome plates have to have a special emulsion, or will the same emulsion do with the screen?

C. D. Hodgman.—A special emulsion is used, and the yellow filters which are used must be fitted to this particular emulsion, otherwise the picture would be too blue or too red.

Member. — Do you use three screens?

C. D. Hodgman.—In the autochrome we have a single screen made up of very many small elements which are so small they cannot be seen by the naked eye; in this case they are actually starch grains, and you really have a multitude of screens. The screens are permanent, and each screen takes its own picture, you might say, and by a chemical process we make the plate transparent behind the particular screen of any color which is represented, so that when we look through we see the same color of light which actually struck the plate at that particular point.

Member.—These starch grains are dyed?

C. D. Hodgman.—Yes. Three batches of the starch grains are dyed and mixed until they appear neutral, and then spread over the plate. The photograph I showed was a microphotograph of the plate, and each one of those spots of color was a starch grain. Of course, they are broken more or less in being rolled.

Member.—Is it necessary to have an expensive lens in your camera?

C. D. Hodgman.—It is not, an f/8 rapid rectilinear lens will do very well.

Member.—There are some lenses that have more or less of a yellow cast.

C. D. Hodgman.—This would be objectionable, due to the fact that they would not give the properly balanced color effect. However, you could have a filter made which would work with that lens as well as with any other, making the filter used outside of the lens a little less yellow than normal. The very best work is done by the so-called apochromatic lens. In the apochromatic lens, three images, formed by three wave lengths, are brought together instead of two as in the ordinary achromatic lens. It would be the lens recommended as the most excellent to use in all color work. The images would be the same size. With the cheaper lens the images are not absolutely the same size. A great many of my photographs show that to a slight degree.

Member.—How does one get a paper print from one of the autochrome plates?

C. D. Hodgman.—I do not believe they do it very well. I think the Hess-Ives process is about as good a paper print process as there is. One might photograph the autochrome by that

process and make the print in that way. The fact that the autochrome is made up itself of small elements of color rather destroys the possibility of making good prints from it. I have seen accounts of several different processes, but I have never seen an account of any one of these processes being widely used, nor anything which could by any possibility be used by the ordinary amateur. I think the Hess-Ives process of making colored prints on paper is better than anything I had previously known of. They make really good prints. Of course, we must not forget the press reproductions which are three-color pictures, and we frequently see very good prints. The difficulty is, that the printing inks, which are permanent, are not quite right in color, but it is possible to improve that considerably by using inks which are not quite permanent.

MEMBER.—What is the cause of rapid deterioration of an autochrome plate?

C. D. HODGMAN.—It is the reduction of the silver bromide.

MEMBER.—Why is it reduced any more in that than in an ordinary plate?

C. D. HODGMAN.—Due to the presence of the dyes and also for the reason that the autochrome emulsion is very thin instead of comparatively thick. The gelatine film on the autochrome plate is just as thin as it is possible to produce and hold the silver bromide. One reason for that is, as I have indicated, that it is necessary to have the silver grains exactly behind the starch grain with which they were first associated. If the film were very thick, as we turned the plate the proper silver grains would not be in line with the starch grains on which they were originally taken. Any cause which would very slightly affect an ordinary plate on its surface would entirely spoil the thin film of an autochrome. Plates which have been sensitized by the addition of dyes are never quite so good in keeping qualities. The difficulty is obviated now somewhat by improvements in manufacture and plates are sold under a guarantee for a certain number of months.

MEMBER.—Did you ever try the Smith uto-color process?

C. D. HODGMAN.—I have never tried that.

MEMBER.—I tried to make some prints by it, but the light in Cleveland is so yellow it takes a long time. I exposed an autochrome three weeks, pretty nearly, and I just commenced to bleach it out. I got the greens and some of the yellow.

C. D. HODGMAN.—It is a bleach-out process. The possibility has long been known, but it is rather a difficult thing to handle.

MEMBER.—When they get white daylight, they can finish them in about two or three hours. But you cannot get real daylight in this part of the country. I find here that it makes a difference in the light whether you expose at four o'clock in the afternoon or at noon.

C. D. HODGMAN.—It makes a very great difference.

MEMBER.—Do you know of the Lippmann process?

C. D. HODGMAN.—Yes, we have a small photograph of the spectrum at the laboratory made by this process. It is theoretically the very finest process of all, but a very difficult thing to use outside of the laboratory, and it does not reproduce the colors quite truly. Stationary light waves are formed similar to the stationary waves formed in a violin string, and at the loops, that is, where the excitement is greatest, the silver is reduced by development and we have a series of films separated by equal distances. These films when viewed by reflected

light give us the color which produced the action.

MEMBER.—Was this confined entirely to the laboratory?

C. D. HODGMAN.—Yes, it is practically confined to the laboratory. It is not a process which would appeal to the amateur at all. The plate has to be exposed with the gelatine emulsion next to a mercury or other good reflecting surface, and it is almost necessary to use mercury in order to get something which will be close enough to the emulsion in order to set up the reflections which will give the stationary wave. That means, of course, a special type of plate holder which we can flow with mercury.

MEMBER.—Is there any known way in which color photography can be applied to moving pictures?

C. D. HODGMAN.—It is already applied in the kinemacolor. That particular scheme, as I indicated, was a compromise in order to reduce the necessary exposure. They use only two colors instead of three. There are certain colors which cannot be reproduced at all by this method, and the fact that the photographs are made alternately first with one color and then the other gives rise to these odd-colored visions we see when anything comes up close to the camera.

MEMBER.—How rapidly can these kinemacolor films be exposed?

C. D. HODGMAN.—I am not familiar with the exact data on that. You need expose a sensitized plate less than one-thousandth of a second to get an impression. But the results obtained would not make good photographically. The usual time between exposures runs down to about one-thirtieth of a second, I think.

MEMBER.—I thought that the color screens would slow it down.

C. D. HODGMAN.—They would slow it down very much. The fact that they do slow it down so much imposes another difficulty in the way of using three colors.

MEMBER.—I might say something about the kinemacolor process. Its chief trouble with exposing the red has been due to the fact that they have not been able to get an emulsion that would take on the red quick enough to balance up with the green and the blue. It is not necessary to move the film very swiftly, or make very short exposures, but one has trouble in regulating the exposure and keeping the red, green and blue exposures constant. As far as showing the positive on the screen is concerned, it is not necessary to show any moving picture faster than sixteen exposures per second, because the eye will not detect a flutter of the film at a speed up to sixteen a second. In the kinemacolor, they use thirty-two, due to the fact they have two different colors, and it is possible to make a machine that will show three times sixteen per second. But the trouble is, in getting a filter that will work along with the blue and the green and at the same time give a proper balance. It is not a matter of expense, it is a matter of finding out the proper emulsion to use.

MEMBER.—For the benefit of the engineers in the audience, I might suggest some experience I had five years ago in the use of autochrome plates for engineering purposes. I had the problem of examining a number of oils suitable for lubrication under conditions of heat and moisture, that is, lubricating the cylinders of steam engines; and the tests which were made consisted in passing steam through them, churning them up into an emulsion, and noting the froth on the top after they had been standing a certain length of time; then after we had determined the characteristics of satisfactory oils, we wished to reproduce them so that we could later on estimate the characteristics of new

oils by optical comparison. It took about six months of experimentation with the autochrome plates before we were able to reproduce the iridescent colors of oils that had been treated with the heat and steam and so on, with sufficient accuracy so that months afterwards we could compare them with new samples of oil and still have a fairly definite comparison; but we finally succeeded in doing it, although I guess we ruined some eight or ten gross of plates before we succeeded.

A Sanitary Interpretation of Water Analysis

By E. C. Richardson

Contributed for Junior Meeting.

Index No. 628.16

A sanitary analysis of a water is made along two distinct lines, bacteriolocical and chemical. The former attempts to show the presence or absence of sewage contamination through the finding of living bacteria that are characteristic of sewage. A sanitary chemical analysis, on the other hand, does not consider living bacteria, but attempts to show by the presence or proportion of certain chemical substances that sewage has found entrance into a water supply.

The usual kind of germs found in water are non-pathogenic, those which will not produce disease. The constituents of sewage-contaminated water that are directly detrimental to human safety are the pathogenic microbes of some infectious disease. The detection of such microbes in a water supply is the most direct evidence of the unfitness of such water for human consumption.

All sewage and sewage contaminated water, however, contains the wastes from human bodies, and such wastes are almost sure, sooner or later, to contain the bacteria of infectious disease. For this reason most of the bacteriological examination is directed toward detecting microbes that normally inhabit the intestine instead of detecting those of specific disease. This is a safe procedure, since water borne diseases, such as typhoid, dysentery and cholera, have their seat of activity in the intestines.

Organisms of these diseases come from persons specifically affected, hence there is more or less uncertainty attending the search for such bacteria, unless there is an epidemic. Normal intestinal bacteria serving as a basis for the detection of sewage contamination are those belonging to the Bacillus Coli group. Its presence in water is indicative of pollution, but to be sure of pollution by sewage its abundance rather than its mere presence must be considered as the criterion. The test for Bacillus Coli in order to be of definite value, therefore, must be not only qualitative but quantitative.

Single isolated determinations of the number of bacteria in surface water are of little value, unless accompanied by a full knowledge of the conditions under which the sample was collected, since rainfall, streamflow, wind and many other factors materially influence the number of organisms present. A single examination may, therefore, lead to erroneous interpretations. Sometimes, however, it may afford some evidence as to the sanitary character of the water; and scattered determinations are often useful in showing the relative character at different times, of water obtained from any particular source. Quantitative bacterial determinations are of special value as affording the best index of the efficiency of filtration. Here each separate test is of some importance.

In the collection of samples of water to be analyzed great care should be exercised in securing a characteristic sample, since it is only by the utmost care in all steps leading to a final interpretation that error can be reduced to a minimum. The sample bottles should be sterilized and care should be exercised to avoid bringing the hand or other objects against the parts of the bottles which come into contact with the water. Hold the stopper by the handle when collecting a sample. Do not lay it

down. Unstopper the bottles only when ready to put the water in and stopper them immediately afterward.

In collecting a sample from a pump, use the pump for at least three minutes just before sampling, taking care that the waste water is carried to a distance so that it will not wash back into the well or cistern. Collect the water directly into the bottle.

In collecting a sample from a bucket, draw up three or four buckets of water and allow the water to waste, using care that the waste water does not wash back into the well. Pour from the bucket directly into the bottle. In collecting samples from a faucet, allow the water to run at least three minutes, then collect the sample directly into the bottle. In collecting samples from a reservoir, lake, or river, hold the bottle by the bottom and plunge its mouth downward into the water to a depth of about six inches; then turn it horizontally, and as it fills move the bottle mouth forward and then upward. In other words, do not let the washings from the hand enter the bottle. The samples should be packed in ice and shipped to the laboratory as soon as possible.

Equal care should be exercised in collecting chemical samples as in collecting water for bacteriological examination.

The chemical determinations that in general constitute a sanitary chemical analysis are, the amount and character of suspended matter, oxygen consumed, oxygen dissolved, nitrogen as albuminoid ammonia, nitrogen as free ammonia, nitrogen as nitrites, nitrogen as nitrates, and chlorine. The results are expressed in parts of the substance determined in a million parts of water.

The object of these determinations is to find out whether organic material from sewage has gained entrance to the source from which the supply of water is drawn. Organic matter of this kind is readily acted upon by bacteria, and during the decomposition, compounds are formed which can be identified and determined with accuracy by chemical methods. The decomposition products of nitrogen containing organic matter are the ones that can be determined most accurately. Nitrogen in albumin-like compounds (or that which is liberated by alkaline potassium permanganate), indicates the presence or absence of the undecomposed animal or vegetable matter containing proteins. Any abnormal amount of these compounds shows the water is polluted.

Nitrogen as free ammonia in any considerable quantity shows that bacterial action on the protein compounds has been carried a step farther, and that ammonia compounds of urea are present. Nitrogen as nitrites yields the information that the bacterial process has gone a step farther, and that oxidation of the nitrogen is taking place. Nitrogen as nitrates shows that the organic material has been completely transformed to a mineral salt which is relatively stable. On the Atlantic coast the chlorine determination is of great value as an indicator of contamination by animal excrement, for every district has a normal value for chlorine. Any excess over this normal amount shows that the water is receiving drainage which probably contains urine. The determination is of little value in the middle west on account of the salt beds underlying the country.

The oxygen consumed tells us how much oxygen is necessary to completely oxidize any undecomposed organic matter.

It may be stated that it is only by comparison with the every day results that the contamination of water may be determined. The quality of water has generally been judged by the degree of sparkle, of turbidity, of temperature, and since the introduction of soap, of hardness. These standards have their value, but they

are considered by sanitarians to be superficial criteria for determining wholesomeness. Water may be hard, warm, flat and turbid and yet be safe to drink; it may also be soft, cold, clear and sparkling and still carry infection.

Wholesomeness depends upon comparative absence of salts and organic matter, deleterious to health. Injurious salts, while inducing disturbances of a more or less discomforting nature, even causing permanent injury if long continued, do not create such serious consequencies as polluting organic matter, especially if this takes the form of pathogenic micro-organisms.

Analytical determinations which relate to the general attractiveness of water are those of taste, odor, color, turbidity and sediment. As these quantities increase the water becomes less attractive for drinking purposes until finally a point is reached where people refuse to drink it. For this, however, a personal element enters. Some people drink a water with relish, while others condemn it. Habit and association have much to do with this.

When it comes to using water for other purposes than for drinking, other attributes have to be considered. Hardness makes a water troublesome to wash with and to use in boilers; iron makes trouble in the laundry; chlorine corrodes pipes and makes work for plumbers; presence of carbonates and sulphates of lime and magnesium affects the paper maker, the brewer, the tanner, the dyer, and the bleacher.

The inconveniences of the use of hard waters are perhaps more important than the money loss involved. In using hard waters for washing the hands and for bathing, the calcium and magnesium stearates are precipitated by the soap and give rise to unsightly scums in the wash bowl and bath tub. They tend to fill the pores of the skin, preventing a thorough cleansing. They also prevent the formation of a good lather in shaving. For culinary operations such as in making tea, hard waters are less satisfactory than soft waters, as they increase the color but decrease the aroma.

The point at which a water becomes objectionably hard has never been exactly defined. The ordinary person washing his hands considers the water soft if the soap will quickly produce suds without curdling. A hardness of 10 parts per million is practically unnoticeable, a hardness of 20 to 30 parts per million being required to produce curdling. Waters which have a hardness below 25 parts per million seldom cause much inconvenience, but when the hardness rises above 50 the water may well be called hard and above 100 very hard. In Kansas a hardness of over 300, which is excessive hardness, is often found. Experiment shows that the hardness of water has a substantial effect on the use of soap. Tests made by G. C. Whipple, in 1903, showed that one pound of the average soap softens 167 gallons of water having a hardness of 20 parts per million. This is equivalent to about three tons of soap per million gallons. It was also found that for every increase of one part per million of hardness the cost of soap increased about $10 for each million gallons of water completely softened. Number of gallons per capita per day completely softened has been estimated by different authorities all the way from 1 to 10. It will certainly be a conservative estimate to assume that one gallon per capita per day is thus softened. On this basis the depreciation of water on account of its hardness may be expressed by the formula $D = H/10$ where "D" is depreciation in dollars per million gallons, and "H" the hardness of the water in parts per million. Applying this formula to a hardness of 112, which I believe is about the hardness of Cleveland water, will give depre-

ciation in dollars per million gallons as $11.20; this takes into account only the cost of soap used for domestic purposes and does not include the incidental losses and inconveniences attendant upon the use of hard water in households. These if they could be expressed in terms of dollars and cents, would probably more than equal the cost of soap.

In most surface waters the physical characteristics vary greatly at different times of the year. During the spring and fall, for instance, the color and turbidity may be high on account of rains, while during the summer the water may have a bad odor due to microscopic organisms.

In Cleveland during the spring the death rate due to typhoid fever increases rapidly. It was found upon investigation that when the ice breaks up along the lake front it carries contamination with it out to the intake pipes. So the sanitary characteristics of a water may vary at different seasons of the year.

The average man when confronted with an adverse analysis of his water supply, is likely to be surprised, declaring that it is the best water in the country and that it has been used for years without producing sickness. Granting that he be right, immunity in the past is no guaranty for the present or the future. Some connection may have been established between the well and outhouse or the cesspool, and apparently he has not happened to harbor a typhoid infected person on the premises. Nothing is needed but the carrier of the specific organism to begin trouble.

Rural water supply is generally obtained from springs, wells, or cisterns. From a sanitary standpoint, springs and deep wells, deep in the sense of entering below the first impervious stratum, are the most reliable sources. The usual excellence of these, and, in fact, of all good ground water, is largely due to the filtering property of the soil. Springs, especially those flowing through fissures, and deep wells, reap the benefit of prolonged filtration through the earth. Both may be subject to contamination, particularly springs, which are often open to surface washings from sewage drains and the like, located farther up the slope. Hence it is advisable to inspect the watershed above a spring; also to guard it from the surface washings by a wall or ditch.

Driven wells and dug wells reach only to ground water, differing in this respect from many springs and all deep wells. Their shallowness brings them at times into proximity to drainage from privy vaults, cesspools, or leaky drains, and anyone sinking a well near these sources of filth must rely upon the filtering action of the soil to remove pathogenic bacteria. The filtering efficiency of the soil, in serving to protect wells from contamination, depends upon such factors as the extent and the nature of the intervening soil and also upon the direction of the ground water drainage.

The distance that should exist between a well and a source of pollution is, because of these, so variable that probably no definite rule would be trustworthy in all localities, other than the greater the distance the better. The course of ground water drainage toward its natural outlet affects the liability of a well to pollution. While it usually follows the direction of the superficial slope, it may take a different route, owing to peculiar sub-soil formation. Therefore, while it is better to locate a well on higher ground than a cesspool or outhouse, it is also prudent to have some distance intervening as an additional precaution.

A well known principle of sanitary science is that of protecting wells against chance of pollution from surface drainage or in filtration. By proper construction and location of a well there is little danger of contaminating the well unless the ground

water itself be polluted by larger sources than privy or cesspool.

Finally it may be said that the maintenance of a wholesome water supply of any kind requires constant attention. To dig a hole to water anywhere, and expect good results forever afterward is unreasonable. With the exercise of common sense, based on the knowledge of ordinary sanitary principles, a person should live in comparative security from waterborne disease.

EMPLOYMENT BULLETIN.

This department is for the use of members desiring positions or requiring engineering services; therefore, if you are in need of engineering help, or desire to secure a position, do not hesitate to call on the department for assistance.

All information is handled confidentially.

At the present time the calls for men to fill engineering and drafting positions demand quick action, and by the time the JOURNAL reaches the members men whose experience we list have been employed. We are, therefore, omitting the list of men in this issue.

We desire all members seeking employment to file an application at the rooms.

We also desire employers whose work will permit thinning down their force to advise us the names and capabilities of men they could permit to withdraw from their forces.

This is for the purpose of securing efficiency in the present great need of our government.

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JOURNAL OF
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General Utilization of Pulverized Coal

By Henry G. Barnhurst*

Paper presented Sept. 18, 1917.

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On receipt of request to present general statements on the subject of the use of pulverized coal, I felt that it was a worthy opportunity to have this privilege and to present to you certain facts concerning the gradual growth and development in the use of pulverized coal for various purposes.

There are no doubt a number of gentlemen present who have been watching the gradual increase in the number of applications of this form of fuel, but no doubt there are many who do not realize, or have any conception of, the importance that is now being attached to the *burning of coals in pulverized form.*

The availability of a fuel of a nature that it can be applied to a large number of different conditions makes it of vast importance to those interested in any development which tends toward economy and reduction of fuel requirements.

Pulverized coal was first applied successfully for economical reasons in connection with the burning of portland cement. The growth of the portland cement industry also had a great bearing on the development and use of pulverized coal in that it is in this industry that pulverizing machines were brought to the present high state of development, for in the manufacture of cement not only the coal is pulverized, but for each barrel of cement manufactured weighing 380 pounds there are required about 600 pounds of raw material such as limestone shale or cement rock, as well as the 380 pounds of clinker produced by the kilns which must be pulverized in order to make the finished product, so that in the neighborhood of 1100 pounds of raw materials, clinker and coal must be ground to produce one barrel of portland cement. As there are a hundred million barrels of portland cement made in this country annually, these figures will give one a reason why pulverizing machines have been so highly developed during the last few years. Fine grinding of the raw material means reduction in the quantity of fuel required and also makes possible the highest quality of the finished product, so far as the chemical analysis or combination is concerned. Fine grinding of the clinker means increased strength for the reason that the hydraulically active units in cement are in direct proportion to the percentage of fines or impalpable powder in the finished product.

This statement is made to impress upon you that equipment for preparing and handling pulverized coal has long since passed the experimental stage and has now been developed to a high state of efficiency and is readily obtainable.

Somewhere between thirty and fifty million tons of pulverized coal have been used to date in the manufacture of cement alone. The application of this ideal form of fuel has been gradually taken up by engineers connected with other industries who have speedily recognized

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its value to such an extent that the steel industry today is using in the neighborhood of 2,000,000 tons of pulverized coal annually in various types of furnaces such as open hearth, heating, puddling, soaking pits, continuous heating, reheating, annealing, forging furnaces and furnaces of practically every description where heat is required, and is being used successfully.

It is evident that the future possibilities of the application of pulverized coal are now being recognized by the large steel companies as a subject worthy of their careful investigation; this is proven by the number of applications now operating and contracted for. The results already obtained make it apparent that this form of fuel will replace other methods of firing in a great many cases.

A great development is going on in the application and use of pulverized coal in connection with the copper industry; ore roasting furnaces, reverberatory and copper melting furnaces of all types are now successfully operating with this form of fuel, and between one and two million tons of pulverized coal are used in this industry alone each year.

Another large field in which pulverized coal is commanding attention is in its application to rotary kilns for the desulphurizing and roasting of various grades of ores and also nodulizing flue dust so as to make available products heretofore rather expensive to recover. In one installation ore is now being treated at the rate of 800 to 1000 tons daily requiring from 250 to 300 pounds of coal per ton of ore desulphurized and nodulized.

In another large installation ores carrying as high as 40 per cent moisture and of rather a soft nature are being successfully handled requiring from 400 to 500 pounds of pulverized coal per ton of ore nodulized.

Pulverized coal is being successfully used today in the burning of lime in rotary kilns for making oxide of lime for use in the open-hearth furnaces, also for burning dolomite to replace magnesite used for furnace linings. The shortage in the supply of magnesite has been responsible to a certain extent for this development.

A still further and very important development is now going on which will, when it attains its growth, require more pulverized coal than probably all of the other industries combined, and that is in its application to locomotives, particularly in the West. This application is now being developed.

There is still another field in which enormous quantities of this fuel will be used and a field in which we are all concerned, and that is in the generation of power in stationary power houses.

There are quite a number of installations now in successful operation using in the neighborhood of one hundred to two hundred thousand tons of pulverized coal annually, and the success obtained by these plants has created so much interest and has brought out so strongly the desirability of the use of this fuel for power purposes, that today there are a number of new installations being made by engineers of national repute.

The peculiar conditions as they exist today on account of the war and for other reasons, the gradual reduction of the supply of fuel such as natural gas and the shortage in supply of crude oils which have become of too much value to be used for ordinary fuel purposes, have compelled those interested to carefully investigate the possibility of the adoption of pulverized coal to replace their present expensive methods of operation and high cost of fuel.

The above statements have been of a rather general nature so as to

bring out forcibly the fact that coal in pulverized form is going to become one of the most important fuels. The results thus far obtained have shown that with proper installations from an operating standpoint it is not only a desirable fuel, but one which will eventually become necessary on account of its economy.

Practically any coal can be burned in pulverized form with a proper furnace and burning equipment. Each application, however, must necessarily be governed by the quality of the fuel available in the district in which it is made. Generally speaking, however, the coals which would give the most satisfactory results would be those in which the ash content would be less than 10 per cent, the volatile averaging between 30 and 40 per cent and the fixed carbon between 40 and 50 per cent. The sulphur content should be low, although coal with a sulphur content running as high as 4½ to 5 per cent is being satisfactorily burned in pulverized form under boilers. The ash should have a high melting point. These statements, however, are tentative as most excellent results have been obtained from all sorts of coals differing widely from the ideal analysis stated.

It is apparent that the development in this method of burning coal has brought coals from which heretofore very inefficient results have been obtained within reach of a great many consumers. For instance, from Texas to Edmonton, Alberta, the country is underlaid with various grades of lignites, low grade mineral coals with high moisture content and of such a nature that the ash would melt or flow down on the grates thereby preventing the highest efficiency from being obtained. They are of such a nature that their use in gas producers is not very satisfactory, so that until the development and burning of these coals in pulverized form was an assured success these coals were not used in as large quantities as is now possible.

The largest deposits of lignite and mineral coals appear to be in the Northwest awaiting future development when proper means are at hand for obtaining the highest possible economy from their combustion, and the location of these large deposits will now be of great value to the districts in which they are located.

Around steel plants there are large quantities of waste fuel such as coke breeze. This fuel is being used to a certain extent on some forms of grates, with forced draft, but it can be burned in pulverized form under boilers for the generating of power and possibly in the open-hearth furnaces for making steel.

In the anthracite field there are large quantities of coal daily pumped back into the mines as a result of the washing and crushing operation for bringing the coal to commercial sizes. This silt or washery waste coal carries as high heat value normally as the coals which have been operated upon. The president of one of the large coal companies here in the east told me that in the neighborhood of eight to ten million tons annually of this silt was allowed to be pumped back into the mines to fill up old workings.

A number of the coal companies are now carefully investigating the application of pulverized anthracite or low volatile coals with a view to using this waste coal in pulverized form so as to obtain power from its use making available coal of higher grade for the market which they are now firing at the present time.

Pulverized anthracite coal is now being burned in one or two installations, and the writer has personally burned pulverized anthracite coal in a special form of furnace.

Preparing and Handling of Pulverized Coal

The coal as received is either in

the form of slack, lump or run-of-mine, and as it comes to the pulverizing plant it should be crushed so that it will go through approximately a 1-inch ring. A single roll coal crusher of approved make is usually the equipment. The coal should then be dried at low temperature to eliminate the moisture. Ordinarily it should be dried so it will not contain more than 1 per cent of moisture. A low moisture content in the pulverized coal as fired in metallurgical or other furnaces leads to uniform temperature conditions which are highly desirable. This condition is also necessary in order to obtain a product of the highest quality; the highest efficiency is also obtained with dry coal.

The drier is usually of the rotary type; that is, the coal is fed into an inclined shell mounted on rollers and is gradually passed through the drier by gravity. The firing chamber is usually located under the shell or is so arranged that the products of combustion from the drier can be used not only to heat the shell of the drier but also to pass through it in order to obtain the greatest economy from the coal burned for the purpose of drying the coal.

The drier should be so arranged that the gases of combustion coming from the furnace do not come in contact with the coal being dried until they are reduced in temperature so they will not ignite the coal. The temperature of the coal being dried should only be sufficient to drive off the moisture; if the coal is allowed to become too hot, the volatile contents may be reduced, thereby sacrificing some of the heat value of the coal. This condition is very readily obtainable, as practice has shown. A pyrometer should be installed to indicate to the operator the temperature to which the coal being dried is exposed. An evaporation of from 5 to 7 pounds of moisture from the coal being dried can be readily obtained per pound of coal burned on the grates in the drier. The amount of evaporation, however, naturally depends upon the quality of the coal being handled in the driers. The driers can also be fired with pulverized coal if desired.

A magnetic separator of some standard make is installed either before the crusher or after the drier so as to remove what may be called tramp iron which consists of pick points, railroad spikes, coupling pins, links, hammer heads, sledges, tobacco cans, nails, etc., all of which have been accumulated, either from the mines or in the crushing operation at the mines. The amount of iron per ton will vary in certain districts, but it is an item of such importance that magnetic separators are being installed in every first class pulverized coal plant which is now being erected. The elimination of this iron naturally improves the pulverizing and conveying operation and prevents breaks and losses due to intermittent operation and wear and tear of the machinery.

Coal as it is passed through a modern pulverizing plant should be elevated and conveyed in dust-tight equipment. After crushing, the coal should be elevated to bins above the driers. These bins should be of ample capacity and arranged with variable speed feeding mechanism so that the driers at all times will have uniform feed. This is very important so that the moisture content will be reduced uniformly and thereby allow close furnace regulation where the fuel is burned. Leaving the drier the coal is elevated and discharged into storage bins above the pulverizers. The storage bins above the pulverizers should be of such capacity that the pulverizing machinery will at all times receive ample feed to prevent them from running empty. All storage bins should be of dust-tight construction, and equipped with deep hopper bottoms so that the coal is constantly in motion while being drawn off. It is in coal lying dormant or stationary

that spontaneous combustion or smouldering action is generated, particularly so where coals are under pressure.

The danger of spontaneous combustion of pulverized coal has been greatly exaggerated. It has been considered that the matter of pulverization increases this danger, but it is a matter of fact that practically nothing more than the usual ordinary precautions taken with all fuels are necessary to guard against it. The mere factor of pulverization is not of any unusual importance as is readily shown in the commercial production of lamp black, which is handled very much like pulverized coal, without bad results. This lamp black is probably 30 to 50 times finer than the average size particles found in commercial pulverized coal. In the lamp black industry, it has been found that only partially filling the barrels when shipping gave much better results than when packing the material up to the top.

Spontaneous combustion is simply the absorption of oxygen. If this absorption becomes too rapid heat will be generated and incandescent combustion will result. The presence of pyrites tends to oxidation to a rapid extent in any fuel, with the probable disengagement of light carbureted hydrogen, and spontaneous combustion results. In the case of lamp black this condition of course is removed as the lamp black contains practically no sulphur, certainly not in the form of pyrites.

Pulverizers of ample capacity to take care of the fuel requirements should be of such a nature that their cost of operation, attendance, power and repairs are at a minimum. A first class pulverizer should be one which can operate if necessary over a period of from one to three months continuously without shutting down even for oiling. The pulverizers should also be of a type that normally delivers a product containing the highest percentage of impalpable powder. Coal should be pulverized so that ordinarily 95 per cent will pass a 100-mesh sieve. The machinery in the pulverized coal plant where possible should be driven by electric motor. The drives should be standardized and the motors interchangeable. Back-geared motors are successfully used in a great many installations, and the pulverizers can be driven either by motors with belt drives or gear driven with a flexible coupling between motor and pulverizer.

Dust collectors are sometimes installed in connection with driers. This dust is formed by the action of the coal passing through the drier, as the coal falls down a certain amount is ground to dust and this dust, being in suspension, is carried along by the air currents through the drier and the dust collector will recover it.

The adoption of pulverized coal for any particular operation naturally depends on the cost of preparation or handling which is a charge in addition to the fuel itself, which charge, however, in a great many cases is less than that where lump coal is used. The power required in a first class pulverized coal plant per net ton of coal handled is in the neighborhood of 17 horsepower hours per ton produced. This includes the power for crushing, drying, elevating and conveying and delivering the pulverized coal to the conveyors leading to the point of use. The repairs vary slightly with the quality of the coal being handled, but generally speaking the repair costs for the pulverizing plant should be somewhere between 5 and 7 cents per net ton of coal handled.

The drier fuel is practically a constant, as the amount required per ton of coal dried with a given moisture content with standard driers will not vary much.

In the Lehigh Valley district where the coals carry from 5 to 10 per cent of moisture as received, 25 to 35 pounds of coal are required to be burned on the grates per ton of coal dried. The cost of this coal is naturally based on the cost of the coal

as received. The great variable in the cost of preparation in pulverizing coal then comes down to the labor item. The labor varies indirectly with the quantity of coal handled and the time or continuity of operation in the pulverizing plant. In other words, the question of labor cost is one directly affected by the equipment installed. One man can handle quite a number of machines, so that in making up an estimate on the probable cost of pulverizing coal careful consideration should be given to these statements.

Generally speaking coal in fairly large quantities from 50 to 100 tons and upwards can be pulverized and delivered to the furnaces at a cost of from 20 to 50 cents per ton depending upon the quantity handled. Nothing has been said, however, as to interest and depreciation, taxes, overhead and other burdens entering into the ultimate cost of preparation, as these are items which have to be considered in each specific case. For instance, the cost of a pulverizing plant, if it is to be operated 10 or 12 hours per day would be considerably greater than an installation to turn out the same production in 24 hours. The cost of preparation will vary also with the investment, for a given production done in one shift will naturally be accomplished at less cost than if it would require two or three shifts.

To make a positive statment as to the cost of any given size pulverized coal plant today is rather difficult, in that the conditions governing every installation vary. Generally speaking, however, an ideal plant with a capacity of 100 tons of pulverized coal daily will cost with the present prevailing high prices in the neighborhood of from $300.00 to $400.00 per ton of coal pulverized. The cost of a plant for 250 tons daily capacity of pulverized coal will be from $250.00 to $300.00 per ton. These are just general statements, however, so as to give some idea as to the cost of pulverized coal plants. Information on this subject can be readily obtained from those familiar with the matter.

To the cost of the pulverizing plant there must naturally be added the cost of the conveying system to the furnaces, also the storage bins, burners, etc., as well as the air supply.

When making comparisons between different methods for burning coal, and in order to be fair and just, the cost of each equipment should be considered from the time the coal is received on the track until it is delivered into the furnace. The storage of the raw coal is a condition always necessary; the conveying and handling of this coal from storage to the plant is also a necessity. The handling of any coal at furnaces particularly with boilers requires the installation of bins and spouts. These items are the same whether stokers or pulverized coal is used for firing. The cost of preparation of pulverized coal as stated above would sometimes lead one to believe that the cost is excessive and that it is a cost due entirely to the pulverizing of the coal, but the cost of preparation as outlined above includes items which are common to any system of mechanical firing. For instance, the distribution of coal in certain plants requires hand labor, so in each case a careful study should be made of the conditions governing the installation, the cost of the present operation, and the cost of pulverized coal installation and its cost of operation, before arriving at a decision as to the advantage of one system over another.

There are too many pulverized coal plants in existence today to permit or allow a careful engineer to be misinformed as to the ultimate cost of the preparation. The cost sheets of plants using pulverized coal for years are readily obtainable.

The subject of pulverized coal handling from the pulverizers to the point of use is also important. The application of any particular method depends upon the distance to which coal must be transported as well as the

quantity to be handled per hour. The general practice in plants where pulverized coal has been used for a number of years and in plants where the capacity would be from about 50 tons per day upwards is the use of screw conveyors for conveying the coal. These screw or spiral conveyors are mounted in dust tight troughs. The gudgeon forming the connection between the different sections of the conveyor runs in chilled bearings and when properly installed its upkeep is very low. They do not require much attention, and the bearings last for years, the coal itself acting as a sort of lubricant. Coal after being pulverized only weighs from 32 to 38 pounds per cubic foot and is permeated with air flowing along the conveyors like a fluid. The horsepower consumption for distribution with this system is the lowest of any, and when properly installed this system is dustless.

There are other means of conveying pulverized coal, such as carrying the coal in suspension. More power, however is required for furnishing air to carry the coal in suspension and at such a velocity to prevent its building up in the blast pipes, than is used where screw conveyors are installed. The necessity of closing up every leak and the possibility of moisture affecting accumulations in the transmission lines make a system of this kind usually expensive to operate.

Another method now being developed is the conveying of pulverized coal through pipes by means of compressed air; with this system the coal enters the pipes in charges, compressed air being used as a means of propulsion. Relief valves and cyclone collectors naturally must be installed so as to relieve the pressure after the charge has been delivered to the receiving point. This system is installed in one or two plants, but its success and operation have not been sufficiently apparent to warrant its installation in plants where a fairly large quantity of coal is handled daily, or for a short distance. This method should be considered where coal is to be transported a long distance.

In connection with tests made on furnaces arranged for pulverized coal at the Calumet Steel Co., the furnace operating in connection with 8-inch mill, the following data are of interest: The scrap material running all the way from small rails 2 feet in length up to 2-inch billets 6 feet long totaling 25,000 pounds daily, being heated, shows that by the application of pulverized coal (the coal being at $2.65 per net ton) as compared with oil at 3 cents per gallon, a saving in fuel of 49 per cent, or $11.75 per day, was obtained. In addition it was found that the average scale, when oil was used for firing, amounted to at least 5 per cent, whereas when pulverized coal was used, there was at least 2 per cent reduction. This 2 per cent reduction showed a daily saving of over $15.00 making the total daily saving by the application of pulverized fuel burning equipment $26.73 and for the year a saving of $6,019.00 on this furnace alone.

At the Atlantic Steel Co., there is an installation of a 50-ton open-hearth steel furnace which has now been in operation since November, 1915. They have been averaging around 400 pounds of coal per ton of steel tapped from a cold charge. This fuel consumption shows the possibility of what may be accomplished in connection with open-hearth furnace practice.

It is evident that there are certain conditions which must be met where pulverized coal is fired in open-hearth furnaces heretofore fired by means of producer gas or oil, they require some changes in the conformation of the flues and neck, the installation of removable slag pockets and rearrangement of the regenerating eliminating a certain amount of the checkers and replacing them by means of baffle walls. The cross sectional area of the flues of furnace and checkers itself must be proportioned properly so

that excessive velocity of the gases is not permitted.

The Lackawanna Steel Co. has been nodulizing flue dust in an 8 x 125-foot rotary kiln. Pulverized coal is used for heating up the kiln and for the ignition flame and it was found that after starting there was asufficient quantity of carbon in the shape of coke breeze mixed with the flue dust to support combustion after being thoroughly ignited and that the kiln operated continuously without the necessity of the ignition or pulverized coal flame at the burning end. I just mention this operation to point out that here appears to be an opportunity for making recovery of a by-product at a reasonable cost.

At the railway shops of the Missouri, Kansas & Texas R. R. for over a year pulverized coal has been in use under their boilers with very satisfactory results. These boilers have been operating continuously day and night and for short periods daily at from 150 to 180 per cent rating. Practically no repairs to furnace arches or walls have been made during the year's operation. Absolutely smokeless operation has been accomplished. The flue gas analysis during some of the recent tests has varied from 15 to 17 per cent CO_2. Coals carrying on an average of from 10 to 22 per cent of ash with a moisture content varying up to 17 per cent as fired are being burned satisfactorily. The furnace efficiency has been very nearly perfect; three tests made in June showed a furnace efficiency of 98.4 per cent, 98.6 per cent and 99.4 per cent.

The pulverizing action increases the superficial area of the coal thereby rendering its combustion far easier of accomplishment and more complete, since each minute particle will be surrounded by sufficient air to insure its combustion. It is evident also that the more finely divided the coal is the more readily it can be satisfactorily burned, and under proper conditions it is absolutely smokeless.

Summing up the whole subject, it may be seen that the use of pulverized coal has no insuperable difficulties to be overcome, but merely those which have always hampered the introduction of new methods. Pulverized coal is here to stay, for it is very closely allied to the conservation of our natural resources.

DISCUSSION

W. M. FABER.—I was rather disappointed in not hearing more on the application of pulverized fuel to boilers.

H. G. BARNHURST.—I mentioned the M. K. & T. installation. I might tell you that there are quite a number of installations now being made in which the boilers will be fired directly with pulverized coal and some which will use waste heat from pulverized coal fired furnaces; for instance, the Sizer Forge Co. is now making an installation in which there are five 250-horsepower Rust boilers, which will be fired either direct or by using the waste heat from the furnaces. The Stone & Webster Corporation have contracted for pulverized coal equipment for close to 8,000 horsepower for the Western Avenue plant of the Puget Sound Electric Light & Power Co., where they are going to replace oil with pulverized coal. They made a series of tests and obtained very good results. The Parsons plant I mentioned has been running since the first of August, 1916. The United Verde Extension Mining Co. is now making an installation of two 439-horsepower boilers to operate at 150 per cent rating. This installation has not been completed. The American Iron & Steel Co., at Lebanon, has been using waste heat boilers for a great many years. It has obtained from the pulverized coal fired furnace between eight and nine pounds evaporation per pound of coal fired in the heating and puddling furnaces, but if I were to mention this example in a number of cases people would say those are waste heat boilers. What

difference does it make if they are using pulverized coal as fuel? The fact that they are able to make the setting stand up when they are burning that form of fuel does not make any difference. The furnaces, under these boilers where they are puddling their iron act as a combustion chamber, and the success of any installation depends upon the conformation of the furnace, that is, the cubical contents of the furnace must be proportioned to the quantity of combustible that is to be burned in a given length of time. In other words there is a certain limit to the velocity at which the gases can pass over the hot surface. For instance the fire brick composing the ordinary boiler furnace becomes plastic three to four hundred degrees below the melting point and if subjected to high velocity, erosion will result and will gradually wear out the walls.

Willard Brown.—In an ordinary rotary drum such as Mr. Barnhurst described in the paper, I would like to know where the best place is to apply a pyrometer, also whether there is any fixed temperature at which the drying gas should be limited in order to prevent ignition of the coal.

H. G. Barnhurst.—The pyrometer should be located near where the coal is discharged from the drier, at the discharge or lower end of the drier, and the temperature should not exceed 500 degrees. When you get above that you commence to distill the volatile matter in the coal.

Willard Brown.—As well as causing the coal to ignite?

H. G. Barnhurst.—As well as causing the coal to ignite. The coal sometimes gets on fire in the drier, which is the case when they are fired too hard.

Willard Brown.—There was another point. You spoke of it being advisable to elevate the coal after it has been dried, storing it in bins above. Is that a matter of choice?

H. G. Barnhurst.—No. The elevator is used for carrying it up so as to get it in the bins above the pulverizers.

Willard Brown.—There is no disadvantage in locating it below?

H. G. Barnhurst.—No. Certain conditions might require an installation of that kind. There is no objection to it. The more elevating of material you get away from the better.

Willard Brown.—Since this fuel is being used more and more, there may be localities where they object to the ashes passing out of the stack. Is there any means of catching the dust and ashes?

H. G. Barnhurst.—No, only this; that by having the combustion chambers properly designed so that the coal as it burns would pass through at a low velocity, a large percentage of the ash will be gathered in the combustion chamber. As it passes through the boiler the gases are cooled, the velocity is diminished and there will be a settling of ash back of the bridge wall. There may be some in the flues and there may be some that goes out of the stack in the shape of a light haze, but it is a clean ash, the carbon is all burned out. And furthermore, I do not think it is nearly as detrimental or in as large quantities as they are forcing out of the stack today where stokers are being used. In New York, in some of their big power plants, they are scattering ash by tons all over the city. I know that, because our office is right near one of the plants, and if the windows are left open too long our desks are covered with it. There are means of catching the ash, but we have not installed any. In some places where pulverized coal plants are located in the center of a city and where we do not want any coal or smoke to get around from the drier operation or from the pulverizing operation, we put in cyclone collectors or settling chambers so that we gather most of the dust before it gets out of doors.

Then with some of the driers we are putting in collectors.

F. S. CURTIS.—In regard to collectors. There is no reason why dust chambers should not be installed, except the extra space required?

H. G. BARNHURST.—That is all.

W. M. FABER.—I do not know whether you made clear or not the allowable amount of volatile moisture in coal. In this district we have coal with the moisture running from 10 per cent to 25 per cent and sometimes higher than that. Of course for pulverizing we probably would not use coal with high moisture.

Another point. How do you determine the dryness of the coal before you pulverize it? Is there any way? You spoke of using a pyrometer?

H. G. BARNHURST.—That is just for regulating the temperature.

W. M. FABER.—Is there any way of testing the coal for the degree of dryness that is necessary for satisfactory pulverization?

H. G. BARNHURST.—We can pulverize coal up to 4 per cent and 5 per cent moisture; for instance, lignite coals which have a certain amount of combined moisture and a certain amount of free moisture. The combined moisture runs about 33 per cent of the total moisture content. If we dry the coal down so that the free moisture is eliminated but the combined moisture is still there it can be readily pulverized carrying 6 per cent to 8 per cent of moisture, but the standard pulverizer today can handle coal up to 3, 4 or 5 per cent.

W. M. FABER.—Is drying the coal a difficult problem?

H. G. BARNHURST.—Not necessarily so. In a laboratory they can make a test to see how much moisture the coal contains.

W. M. FABER.—They cannot make that test on coal as shipped to us. We have to take the coal as we get it.

H. G. BARNHURST.—Of course, the operator soon finds out whether his coal is coming out of the drier a little too wet, and he stirs up the man who is operating the drier; but the cost of removing the moisture, so far as the operation of the drier is concerned, is a small item of expense, and so they play safe and usually get the coal a little too hot rather than not hot enough. There is no quick method I know of except taking it over to a laboratory and making a determination for moisture. But the men soon get to know about how dry it ought to be to be pulverized.

W. M. FABER.—There are quite wide limits then to the degree of dryness?

H. G. BARNHURST.—Yes, but ordinarily they find out how long it is necessary to dry the coal so that it will contain about 1 per cent of moisture and less. Coal should be dried so that it will be under 1 per cent, because it is economy to drive off the moisture at a low temperature rather than let it go into the furnace.

W. M. FABER.—I would like you to bring out a little more information on burning and pulverizing coke breeze.

H. G. BARNHURST.—All I can say in that relation is that pulverized coke breeze will burn just like petroleum. It runs low in volatile matter, 6 per cent or 8 per cent. We burned it in a special form of furnace. When I speak about a special form of furnace, we had one under a 400-horsepower Rust boiler at the Allentown Portland Cement Company where we burned pure anthracite as well as coke breeze. Coals with a low volatile content do not burn with the rapidity that coals with the high volatile content do. The ignition does not travel back against the incoming jet. The result is you have to bring the heat back to the nozzle or point of entrance and it becomes self-supporting in that way, which cannot be accomplished in any other way.

Wherever they have tried to burn anthracite coal or low volatile coals without a secondary flame it has been a failure. The only way possible to burn it satisfactorily is to return some of that heat from the furnace to ignite the incoming coal. These tests were made for the purpose of finding out what we could do. We burned satisfactorily anthracite, coke breeze and coal or dirt from the washing of coal for making coke, and this dirt had 48 per cent combustible in it and 52 per cent ash. It appears that the quantity of ash in the coal does not cut much figure as long as there is carbon enough to burn and give a good flame, but it would not be practical because we would have to grind two tons of material to get one ton of combustible, which would be a rather expensive proposition.

W. G. Stephan.—A few months ago I had the pleasure of investigating powdered coal. During my travels I saw Mr. Barnhurst in his "sanctum sanctorum", and after talking to him about the appartus for powdering coal, I visited the plant of the American Locomotive Works at Schenectady. I was particularly interested in its application to boilers, and there I found a Franklin boiler in a very poor setting, equipped with powdered coal apparatus apparently doing very satisfactory work. The engineer suggested that I make a gas analysis. He had no previous knowledge of our coming, so I made an analysis at once and found between 15 per cent and 16 per cent CO_2, which showed very good combustion. The peculiarity of the installation was their method of introducing the powdered coal. They brought the coal itself in a spout to the burner, and then it was projected into the furnace by steam; in other words, it was a steam injector used for feeding coal.

I would like to ask Mr. Barnhurst regarding the flexibility of powdered coal for boilers. In a modern power plant the boiler must be designed for from 100 per cent to at least 200 per cent of normal rating. This must be accomplished if powdered coal is to be used in central station plants. I might mention also that one of the things we wanted to investigate was the character of the ash from powdered coal burning. We found that in this Schenectady installation the ash was so fine that it could be removed very easily with a shovel or a hoe. I had the impression it formed slag and was hard to handle, but it was a simple matter to remove it in this case.

W. B. Hanlon.—Will pulverized coal give better results in open-hearth work than if used in a gas producer?

H. G. Barnhurst.—I believe it would.

W. B. Hanlon.—The question came up recently where a steel company specified coal of 35 per cent or more in volatile, and the laboratory tests showed the coal filling the specifications with several per cent to spare. A test of that same coal from the mines tested for gas-producer work failed to give satisfactory results. It is a question whether, if they would use that same coal pulverized, it would answer the purpose or not.

H. G. Barnhurst.—I should think it would. For instance, at Parsons we had the best test with the lowest volatile coal which ran down as low as 20 per cent. I venture to state steel will be made from anthracite coal which contains 1½ per cent to 2 per cent volatile when the furnace is being heated alternately from one end to the other. In the open-hearth furnace, each time there is a fresh charge of coal injected, by reversing we have an intensely heated chamber to receive it, and it ignites instantaneously. I fully believe that better results will be obtained with the same quality of coal when pulverized, one furnace using producer gas and one using pulverized coal, and that the use of pulverized coal will reduce

the quantity of fuel required from 30 per cent to 40 per cent as compared with the gas producer. This seems to be the general result. There are a number of installations now being made, and we will have more definite information in a short time. I know that at the Atlantic Steel Company they are getting remarkable results. The plant has been running for nearly two years. There are a number of larger installations in western Pennsylvania, around Pittsburgh, being made on account of the shortage of gas. How far we can go in reducing our volatile content or how high in ash coals can be used remains to be seen. I know coals have been used recently where the ash has been running as high as 17 per cent, but it is liable to choke up the checkers, particularly in installations where the checkers have not been designed for pulverized coal firing, but for some other fuels. When it is adopted as the standard method of burning, then the checkers will be designed so that the ash can be removed while in operation, and there does not seem to be anything particularly hard about arranging them that way.

ED. LINDERS.—Is it necessary to make any change in the shape of the furnace proper; the combustion chamber, so to speak?

H. G. BARNHURST.—No. One condition we would like to have, would be not to have the necks too long. We would like to have a distance of not more than 16 to 18 feet from the point of entrance of the fuel to the edge of the bath, but when the flues in open-hearth furnaces are not designed for pulverized coal too high a velocity is the result. The velocities want to be rather low where pulverized coal is used on account of the erosive effect developed where too large quantities of coal are fed into the chamber not proportioned for it.

J. B. CLAPPER.—How about the application of this fuel to small forging furnaces, etc.? How small furnaces are they being used on now?

H. G. BARNHURST.—It is being used on a number of small heating furnaces, for instance the American Iron & Steel Co. and others are operating certain small furnaces where they are as small as two feet square. I know of one plant where they are now putting in a large installation in connection with forging furnaces where they made a test of a day's run; if they had used coal hand-fired they would have used about 14,000 pounds of coal, but with pulverized coal they used only about 4,800. Where they took an hour and a quarter to heat a 12 x 12 billet, when they used pulverized coal they got it out in 45 minutes and they were able to push the capacity to the limit. We were talking a minute ago about firing conditions in connection with the boilers. In a good many power houses one must be able to take care of peak loads at times. With pulverized coal all you have to do is turn on the coal and air supply. The furnaces must be designed to suit the maximum rating at which the boilers are to operate and the feeders must not feed more coal than the installation was designed for, or destructive conditions will ensue.

W. G. STEPHAN.—Powdered coal forging furnaces may be seen at the Transue & Williams plant at Alliance. They have used powdered coal for a number of years.

H. G. BARNHURST.—Yes, we are making at the present time a very large installation at the Sizer Forge Company's plant. They will be four-door furnaces from 32 up to 48 inches square doors.

C. C. SMITH.—I had two or three years of experience with powdered coal when I was at the McCormick plant of the International Harvester Co., in Chicago, in their malleable annealing furnaces. We had ample grinding capacity and so as a side

issue as long as we had enough powdered coal to burn, we tried it in our boilers, and one of our members here, Mr. Neville—I don't know whether he is here tonight—will have a distinct recollection of that experiment. The boilers were, as I recollect, of the Heine type, and those horizontal baffles certainly did love to collect the ash; we had a great deal of trouble getting it out of there. It was very successful if we took enough pains to keep the boiler blown out. It showed good economy, but we were using coal for the annealing furnaces that we bought as cheap as possible, and it ran 15 per cent to 20 per cent of ash, plus about 20 per cent of moisture. The men at the mines had passed it under their sprinklers before it was weighed and charged us coal prices for water. We came to the conclusion on the boiler proposition that boilers with vertical tubes were much better for using pulverized coal than horizontal tube or pass boilers, because ash collected on top of those 2½ to 3-inch horizontal tubes and reduced the value of the heating surface.

H. G. Barnhurst.—If you will consider the amount of coal you were burning and the size of the combustion chamber you were putting it into, I think you will see that is a part of the installation you did not give much thought. The general concensus of opinion was that pulverized coal could not be used under boilers because they had taken pulverized coal from an operation something like a rotary kiln and injected it in under their present setting, when such setting was designed for burning lump coal; the result was destructive conditions ensued, and it was thrown out as being no good when really it was thrown out due to ignorance of the subject.

C. C. Smith.—We had an interesting test of the smokelessness of burners. By turning the valve one way we got black smoke coming out of the stack, and turning it the other way we got no smoke whatever. We could regulate it at any boiler so that it would smoke or not smoke.

H. G. Barnhurst.—I went up to see some of the men up in the anthracite field, where they have great quantities of waste fuel, and I endeavored to get them interested in the use of pulverized coal a number of years ago. They were all somewhat selfish. Every engineer, I remember, had to be convinced. Each one had a scheme of his own. They all said they had tried out pulverized coal 15 to 20 years ago. They did not know how to pulverize coal 15 years ago. The result was we could not get a chance to show what we were trying to do. We tried to work up from the bottom, now we work from the top down, and I believe will accomplish better results.

John McGeorge.—Speaking of the open-hearth furnace gases, you said that they were regenerated up to 2,000 degrees. What were the outlet flue gases in that case?

H. G. Barnhurst.—I could not tell you that without reference to some data. I have a number of tests, and I would be very glad to send you readings that were taken throughout the setting.

John McGeorge.—You spoke of taking away the gas regenerators. Did you not use these also on air?

H. G. Barnhurst.—No.

John McGeorge.—In the use of natural gas, when gas regenerator is no longer needed it is customary to put this regenerator also on air.

H. G. Barnhurst.—They have done this at some places. At Donora the furnace was built so they could eventually put in gas producers, but we only use one regenerator for each furnace.

John McGeorge.—Is that double size?

H. G. Barnhurst.—No, they are not increased very much.

John McGeorge.—I thought you wanted them increased so as to reduce the velocity.

H. G. Barnhurst.—We do. We allow between 40 to 60 cubic feet per ton of steel. That is the proportion we have. The larger you get them the better it would be. We do not increase them anywhere near the size that you would require for a double set at each end. There is a great saving in the amount of regenerative brick work. We eliminate a great many of the checkers on account of the small quantity of air that is passing through. Seventy-five per cent or 80 per cent of the total air is required, the other coming in with the coal. We do not need as much total regenerative capacity as we would if we were burning the air with the gas, and the result is we have eliminated a great deal of the checkers.

John McGeorge.—I remember a Wellman design which provided a removable bottom for the regenerators at the chamber end.

H. G. Barnhurst.—With the sliding bottom?

John McGeorge.—Yes, is that what you recommend?

H. G. Barnhurst.—Yes, because some of the ash will be carried over and deposited where the gases change direction. Our ideal design is to have the gases come down, swing around and then come up and over and down through the checker. The result is that with the change of directions there is deposited a large percentage of the ash carried in suspension. The removable slag pocket is a construction that has been in use for many years.

C. C. Smith.—We tried our best to find a use for the ash that we got out of the bottom of those big annealing furnaces which was left in these chambers.

H. G. Barnhurst.—Was there any combustible in that ash?

C. C. Smith.—No. We used a Raymond air separation mill, the coal being as fine as flour, and we burned out all of the carbon except during the first few hours of starting up with a cold furnace. But we hunted our heads off to find a way to use that ash, because we had a young mountain of it. I wondered if anybody else had ever tackled that. We tried to use it with fire clay for setting fire brick and we tried it for a number of things.

H. G. Barnhurst.—I do not know what you would do with it; it is a kind of waste. They are looking into pulverized coal in connection with glass manufacture. They tell me they have used some of the ash in the producers in the manufacture of certain kinds of glass.

Ed. Linders.—You stated that the pulverized coal was carried up above the pulverizing arrangement and then passed through a screen and then down. Is there any tendency for that pulverizer to clog in any way, that is with the material not being pulverized fine enough and new material feeding down from the top?

H. G. Barnhurst.—If you had too much moisture in your coal it might clog, but that is a condition that is under control. The material is elevated. The screens are not put in so much to regulate the fineness as to regulate the velocity of the air passing through the mill. The air passing up from the grinding zone will carry certain degrees of fineness at certain velocities. If the velocity is increased you will get coarser particles out. Our coal is ordinarily ground so that 70 per cent will pass through a 300 mesh sieve. The screen on the mill is only a 30 or 35 mesh screen. If the material went straight through the screen it would give you 30 or 35 mesh product. It is passed around at a higher velocity, and the result is it comes through with a high degree of fineness and the particles that are too coarse to pass the screens are returned for further pulverization.

The greater surface exposed the more rapid is combustion so that a machine that takes material out before it is properly reduced is not as satisfactory as one which produces the highest percentage of impalpable powder, although in both cases the screen tests may be the same. The screen test does not mean a great deal. It only tells or indicates what the residue is. It does not tell you anything about the material that passes through the screen.

W. M. FABER.—We are all interested in coal economy, of course, more especially since coal is so high in price. We want to know what you might expect in the way of economy in fuel by using powdered coal. For instance, it is possible to heat a ton of billets with 2,100 cubic feet of naural gas, of about 1,000 British thermal units per cubic foot. That is equivalent approximately to about 170 pounds of coal at 12,500 British thermal units. With pulverized coal can we expect as good practice as that on a British thermal unit basis with the same type of furnace?

H. G. BARNHURST.—I think so, Mr. Faber. I have some records right here showing the amount of coal, if you would get the same British thermal unit.

W. M. FABER.—The same furnace efficiency.

H. G. BARNHURST.—You would save 25 per cent cost, is that it?

W. M. FABER.—No. Twenty-five per cent in fuel consumption; that is, over our present practice with gas producers. The present practice with gas producers is about 210 to 225 pounds of coal per ton of billets (4 x 4 inches) heated. We certainly expect to do better than that with pulverized coal. We expect to bring it down to the equivalent of 2,000 or 2,200 cubic feet of natural gas per ton of billets.

H. G. BARNHURST.—All I can say about that is that I think you will be below 200 pounds, and that you will approach the British thermal unit consumption you are using with natural gas for the same class of work. Mr. Harrison came to my office the other day and said that he was using gas producers on continuous ingot heating furnaces, and that he was using between five and six hundred pounds of coal per ton of ingots heated. He is now going to take out the gas producers and put in pulverized coal.

W. M. FABER.—Under 200 pounds?

H. G. BARNHURST.—Yes; he said he expected to cut down fuel consumption to under 150 pounds.

W. M. FABER.—I think soaking pits against furnaces.

H. G. BARNHURST.—No. Continuous heating furnaces as against a soaking pit.

F. S. CURTIS.—A few points with reference to agriculture seem to be rather remote in a discussion of this kind, but it is a well known fact that in the manufacture of commercial fertilizers they frequently have call for what they call a filler. We were speaking a moment ago of the disposal of ash. When I was informed on the chemistry of fertilizers, I believe I heard it said that ash of this nature is beneficial to the soils, and undoubtedly in most commercial fertilizers it would not prove detrimental, and it might be right there would be a good chance to make disposal of this ash.

H. G. BARNHURST.—I should think that would depend a great deal on the analysis of the ash and the district in question. I know there are certain places in the west where they have 8 per cent or 10 per cent of lime in the ash and 20 per cent or 30 per cent of iron. It might be that an ash of that kind would be very beneficial to the soil. Generally speaking, I do not know if the ash from furnaces of that type would be of value.

F. S. CURTIS.—They use just plain sand sometimes as a filler.

J. H. HERRON. There is a point not brought out relative to Mr. Stephan's account of the boiler at Schenectady. He said that the setting was poor. At the same time the CO_2 content of the flue gas was high. One of the losses in the indifferently made boiler setting is infiltration of air. Where there is a large quantity of excess air your CO_2 is low. The thought has come to me that possibly under blast conditions the furnace is slightly under pressure. Is this so?

H. G. BARNHURST.—Very slightly.

J. H. HERRON.—That would be an indirect saving but nevertheless desirous to consider. There would be better or no infiltration of air through defective settings.

H. G. BARNHURST.—I might mention that in some tests we made at Parsons in June that the draft in the furnace, other than that which came right in with the burner, was about one-tenth of an inch. That will give you a little idea as to the conditions there. We want a very, very slight suction rather than a pressure in our furnaces so that there will be no puffing action.

J. H. HERRON.—No blowing back?

H. G. BARNHURST.—No blowing back or puffing.

J. H. HERRON.—The question came up about metallurgical furnaces, especially small furnaces. This summer I was very much interested in hearing a discussion at the meeting of the American Drop Forge Association, which was held in Cleveland. There was a spirited discussion on the use of pulverized fuel in small forging furnaces. The small forge furnace as applied to the drop forge plant is operated at temperature of about 2,500 degrees Fahr., and at times higher than this temperature. The quantity of steel heated per unit volume of the furnace is large. The concensus of opinion at that discussion was that pulverized fuel was not adaptable to the drop forge furnace which has been developed for the use of gas or of oil. The reason for this has been made clear by Mr. Barnhurst in his statement that there must be a given ratio of furnace volume to the amount of coal burned in a given time. Possibly Mr. Barnhurst can state what the ratio should be.

H. G. BARNHURST.—That ratio will vary. Our practice is to allow about 40 cubic feet in a furnace per pound of combustible burned per minute. At Parsons we were only running at about 125 per cent rating, and we had nearly 50 cubic feet, but this is not a fixed ratio. I think that with coals at low melting point it will be necessary to have somewhat larger ratio whereas if the ash is of a high melting point the ratio can be cut down considerably, but in general for the furnaces we are designing today we are using 40 cubic feet per pound of combustible burned per minute, which will give us a very low velocity. The ratio cannot be fixed. The shape of the furnace has something to do with it. You can easily get these contents and at the same time have a small cross-section area. Take a furnace in the form of a cube, this rule would hold good, but if that furnace was long and narrow, the velocity might be too great against the surface of your brick work and wear it away. The burners do not want to be too close to your brick work either. There can be no fixed rule, but I am of the opinion that the question of the melting point of the ash has a good bit to do with it.

J. H. HERRON.—Has the volatile constituent of the coal a marked effect on the ratio? That is, with coal of a high volatile constituent which probably burns more rapidly than coal with a low volatile constituent could the ratio be reduced?

H. G. BARNHURST.—Well, in some of the tests that are being made now in the east with the boilers operating well above rating no serious effect was observed while running even

though the volatile content of the coal was fairly high. But we not only like to have the contents of the furnace proportioned to the quantity of coal that is being burned, but we like to keep our burner as far away from the flues as possible so that the combustible will have plenty of time to be thoroughly consumed before it strikes the cold surface of the boiler. The same thing is occurring today in stoker practice. For instance, at the Delray plant of the Detroit-Edison Company, these boilers have 25,000 square feet of heating surface. They have very nearly 50 cubic feet when they are operating at the highest capacity, and the distance is considerable from the grate to the heating surface of the boiler. So, in addition to the proper cubical contents, we want as long a travel as we can get.

Ed. Linders.—What kind of a nozzle is desirable for using powdered fuel a circular orifice or rectangular?

H. G. Barnhurst.—Each different operation will require a different treatment. In the open hearth we use a six or seven ounce pressure, with a small jet of about one or two per cent of the air injected right in the center of the large jet to break up the coal. In cement practice we use seven ounces and let it go in there as a solid column, and we only put in with the pulverized coal about 20 to 25 per cent of the air required for combustion. In our forge practice we put 100 per cent in through the burner and fog it in at very low pressure, so it requires a burner of an entirely different nature. The size or diameter of the nozzles that go in the burner all depends on the quantity of coal you are going to burn. We usually allow 50 per cent of the air to be blown in, and that induces the balance by suction and also reduces the pressure so it fogs in at a low pressure. So you would have to tell me what particular operation you refer to in order for me to tell how to make the burner to suit that condition.

H. V. Schiefer.—Do you have any particular trouble with explosions in your bins, elevators and conveyors?

H. G. Barnhurst.—Today we are grinding from ten to fifteen thousand tons of coal daily in 30 or 40 plants in the Lehigh Valley district. The last accident we had of any serious nature occurred about five years ago at Martin's Creek. At this plant they attempted to blow up some foundations in the coal plant while it was in operation. Some of the coal in the form of dust floats in the air and settles. Whether you can see it or not, it is there just the same, and in blowing up these foundations some of this coal which had settled on some of the rafters overhead was set loose and came down and was sucked into the fire, in the drier, which gave a big puff and a couple of men nearby were burned to death. An experienced operator would not have done that. If these men had followed the rules and regulations that were established in these plants an accident like this could not have occurred.

The most serious accident before that was 12 to 14 years ago at the Edison cement plant. They treated pulverized coal down there by means of passing it through rolls and as it was reduced to a certain degree of fineness it was separated by air and the coarse tailings passed through the rolls again. It was not a pulverizing action; it was a powdering action, and the product they made was in comparison equal in size to cobble stone as compared to the present product.

An explosive mixture of coal and air always existed and it was ignited in some manner and four men were burned and nine men were killed, including the chief engineer of the plant. That was the most serious accident that ever occurred through using pulverized coal and it happened because no particular attention had been paid by the engineers who built the plant to what the previous prac-

tice in coal pulverizing plants had been. They went ahead on entirely new lines disregarding the standard practice and the result was a very serious accident, and it gave a general impression that pulverized coal was dangerous to handle. It is not. It is not as dangerous as oil and, when properly handled, it is perfectly safe. You naturally do not want to use any open torches where it is being pulverized.

H. V. SCHIEFER.—Explosions in the conveyors and elevators are unheard of?

H. G. BARNHURST.—No, they are not. The coal will occasionally catch on fire by oxidation, maybe a little moisture, or it may become too hot in the drier, but explosions do not occur unless the elevator is opened and there is an explosive mixture there and a man happens to come along with a cigar or torch. But we have very few explosions. You can touch pulverized coal on the floor with a match and it will just smoulder and burn. But when you get it in the air in an explosive mixture, it will go off as quickly as a snap of your fingers. It is pretty well under control today, and the men know what they can do with it and what they cannot.

WILLARD BEAHAN.—There is a pile of coal at Springfield, Ohio, on the Big Four Railroad that has been giving trouble for the last month. The pile contains 80,000 tons. The bottom of the pile is soft lump coal. The top of the pile is mine-run, as they could not buy lump coal any longer. It commenced to smoke about a month ago, and instead of getting after it properly, as they should have done, they poured a good deal of water on it, and tried some few expedients. It was getting worse. They had no steam shovels of any size. About a week ago we were called to send two large shovels and three crews to load it out. Springfield, Ohio, is a very nice city, you know, 62,000 people. The pile is quite well in the center of the city. It is so very bad there that it is a public nuisance, and we were criticised very severely. You cannot stop there but what you smell the gas at once. It is tarnishing all the silverware in town, and the people are very violent. They have a city manager there. It has come to be a public nuisance there. Now, of course, that is one of the things we have to contend with in railroading, this spontaneous combustion of coal. What we do when we have neglected it in this way is to load it out, putting it in cars, turning the hose on it and use it up in our locomotives. That is really the remedy we have followed. It is rather an expensive remedy, and very troublesome. It knocks out your men, the gas is so bad. It makes you hoarse, makes your eyes run.

A few years ago when I was trying to help out in this matter and eating as much gas as the rest, I did think to myself for a few minutes I was as near to hell as I desire to be. Of course, that is a mere matter of opinion, but in a practical way that is the railroad trouble with this coal. It is run-of-mine, of course, and it is run of different mines, some worse than others. But when we pile our lump coal more than 18 feet deep, our experience is we are apt to have this trouble, so we take plenty of space and scatter it out. There are only two ways to guard against it. One is to drive down what we call breathing pipes, 4 to 6 inches in diameter, plugged at the bottom, and a lot of perforations up for some distance. Then of course we drop a thermometer down there and test the temperature every once in a while. Sometimes we do not go to that trouble. We drive down a small pipe and do not stop up the bottom. We found out by experience on the New York Central that you keep the temperature below 150 degrees there is no danger whatever. It is when it gets up to 150 degrees that we commence to dig down with something and go down as deep

as we can and keep loading it out all the while and put water in there and cool it down below 150 degrees. That has been our way of getting at it. It is not at all scientific, but we have not had any trouble when we paid attention to our business. If all railroad men knew their business and attended to it, the company would not need white bearded fellows at all, but they do not do it. The Superintendent who gets foxy will pile coal as high as he can, sometimes 50 feet, and then, of course, there is trouble. And when fire starts in one of those coal piles, it is not an easy thing to stop. What we do is to take the coal away. We get a shovel so big there we can load it up faster than fire can spread in it, and then we lecture the man who piled it so high and tell him not to try to put it all in one space.

E. P. Roberts.—As to installations for burning powdered coal in boiler furnaces "designed" for the usual coal, I would suggest that only a very small percentage of boiler furnaces are designed for the conditions under which they are expected to, or do, operate. Usually the furnace has certain dimensions relative to the boiler and they are not based on, or varied with, the amount or character of the fuel, the rate per square foot of grate, the draft, the characteristics of the ash, the amount of air and products of combustion, the volume as affected by the amount and temperature, the cross section as affecting the velocity of the gases, the length of flame travel, etc.

If those responsible for installing powdered coal become informed by such men as Mr. Barnhurst as to the importance of design for conditions, it will be of great value, not only as to burning powdered coal but also as to other fuels.

The degree of fineness of powdered coal essential for complete combustion, depends much on the length of flame travel and this in turn depends on the design of the furnace, and the pressure, velocity and direction of the stream, but a large part of the coal, as now desirable, must be exceedingly fine and not measurable or comparable by consideration of 200-mesh sieve percentage. It is like Ivory Soap, "it floats."

A useful and easily remembered figure is that at furnace temperatures, and allowing 15 pounds air per pound of combustible, the gaseous products of combustion will occupy approximately 1,500 cubic feet, the increased volume as compared with the entering air being from seven to eight times. Fifteen pounds is low for coal not powdered, and 18 to 20 not bad, and 20 frequently materially exceeded.

Relative to locomotives, possibly more important than fuel efficiency while running, is total fuel used. The present "stand-by" losses are frequently 30 to 40 per cent, depending on service, and sometimes even greater. This may be largely reduced by burning powdered coal, or oil. There are many other considerations; maintaining pressure, lessened labor for fireman and conserving his eyesight (now injured by firing) and thereby increasing the number of men who graduate from the left to the right of the cab; having two men to watch signals; using coal not otherwise used, anthracite "slush", etc. Also lessening lost time of locomotives in round house, etc.

As to preventing the escape to the outer air of particles in suspension in gases, much work has been done along the line of electrical precipitation (Cottrell process) and washing, but, at present, the applications, economically considered, are somewhat limited.

Factory Fire Protection

By J. C. Gillette*

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While I do not in any way pose as a fire fighter or an authority on the rules and regulations of the National Board of Fire Underwriters, I have always been interested in this work; in fact, one of my earliest recollections as a kid is of an old hand-power fire engine working on a fire in a neighbor's barn. I presume the reason I remember it so well is that I set it on fire.

I do not expect to tell you anything you have not known for years, yet I do hope to provoke some discussion that may lead to our giving our fire risks a little thought; to stopping in our rush for production for a moment to see if everything is being taken care of as it should; to check up those temporary additions to see if they have been protected as far as possible; to see if that new man we have had to put on because Jim or Jack has gone to the front knows and does what he should to make the plant safe.

I am not going to inflict a re-hash of the Underwriters' rules on you tonight relative to safe methods of building construction. You do not want or need that. You know that on permanent construction it pays, and pays big, to follow their rules; in fact, so well are they drawn that I believe if a factory were built and equipped strictly according to their recommendations that you could not set it on fire; but the thing that concerns us most is what we can do with our present plants, with their congested out-of-date construction, working every square foot of their space 24 hours a day, as some of you are, to minimize, as far as may be, our fire risk.

*Master Mechanic, National Carbon Co.

I wonder if you realize just what our fire loss really is. It is so large that dollars and cents do not give us any real understanding of it. H. W. Foster, in *Safety Engineering,* has an illustration that gave me a better idea than I have ever had:

"Picture, if you will, a street 1,000 miles long, extending from New York to Chicago. On both sides of the street for the entire distance, and occupying an average frontage of only 65 feet, are homes, factories, stores, schools, churches, and all other types of buildings which man erects for his convenience. Picture these buildings teeming with life, women and young children in the homes, the factories humming with industry, the stores manned with their work forces and thronged with shoppers, the schools attended by tens of thousands of children, and the streets filled with people and with conveyances hurrying about their business. Consider the courage, effort and material which have been required to bring about the situation. Then picture, if you will, a fire, breaking out in New York City and spreading westward along this street at a rate of three miles a day, reaching at the end of the year the other end of this highway. There you have graphically what we suffer in the way of fire losses each twelve months.

"If we were to walk along that street of desolation, we would come upon an injured person every 1,000 feet, and upon a corpse every half mile.

"Such has been the annual sacrifice that we have offered on the altar of the god of fire. As in ancient days, burnt sacrifices have brought no returns."

You think, as all of us do today, "Yes, that is terrible, but I don't believe my plant will be caught in it." Let me give you an instance of a modern plant, well equipped and rated as a good risk, that was totally destroyed, and here is what the investigation developed:

Fire started shortly after 4 p. m. on Saturday afternoon, Feb. 10th, in a room used for storage of old office records. About 1 o'clock on the day of the fire it was necessary to shut off the sprinkler system in this building to repair a frozen sprinkler pipe, and after this work was completed it was not turned on as it was feared that the system might freeze, as this had occurred two other times within the week. The fire was discovered by the Janitor before it had attained any great headway and the alarm was promptly given. The first men on the scene tried to use the small hose attached to the sprinkler system but got no water, as the riser was shut off. The local fire department responded promptly, arriving ten minutes after the fire started, and attempted to use a yard hydrant, but got only a dribble of water. They then tried another yard hydrant but found the same condition. As there appears no reason to suspect the yard mains were obstructed by ice, it is very evident that the main valve on the public water supply to the fire service system was shut at this time. The chief of the local department says that when he arrived one good hose stream would have extinguished the blaze. After the firemen had failed to find water in the yard system they withdrew from the yard and coupled onto the street hydrant where ample pressure was obtained although the hose lines were extremely long. Additional engines had been summoned by telephone, and on arrival, they were informed there was no water in the mill yard mains but no one examined the valves to find out why, all taking up their stations at the street hydrants, with the exception of one steamer which took its suction from the mill reservoir. The fight that was made to save the building with the hose streams from the outside was entirely unsuccessful, no attempt being made to concentrate and hold the fire at the main fire wall in the center of the building.

In addition to the primary supply the fire protection system was supplied secondarily by a 1,000-gallon Underwriter steam fire pump and a 1,000-gallon electrically-driven rotary pump, both taking suction from a 450,000-gallon reservoir.

When the fire broke out the steam pressure was down to about 20 pounds, owing to repairs to arches and grate bars.

The engineer, after getting the alarm, went to see where the fire was, then returned to the pump room to start the pump after shutting off steam supply to the main building at a valve in the pipe tunnel. Altogether, it was 40 minutes before the pump was started and then it could not be run at full speed. There was a delay of one hour and 45 minutes in starting the rotary pump, this pump being driven by gas engine-driven generators and the compressed air tanks for starting same were empty and they had no steam to start the compressors. At the same time current from the local electric company was available at the switchboard a few feet away but there had been no connection made between the two bus bars. These connections were made and finally the pump started.

Although instructions had been given to close all fire doors in the fire walls, several were found wide open after the fire, probably plugged open.

The fire pumps which took supply from the 450,000-gallon cistern ran until the cistern was empty. The steam pump then lost its water and ran away, breaking a gland on one steam cylinder. The first steps on the controller of the electrically-driven pump were burned out when started;

✓ DENOTES O. K.

N REFER TO NOTE

FIRE PROTECTION -- INSPECTION REPORT

NATIONAL CARBON COMPANY., FACTORY "A"

Date ____________

Inspected by ____________

Fire Extinguishers Chem. & Pyrene	1 1A	2	3 3A 3B	4 4A	5 5A	6 6A 6C	7 7A	8 9 9A	10 10A 10B	11	17	18	19 19A	20	21 21A 21B	25	27	29	30	32	37	38	40	43	44				P. P.	L. B.
Number	5	26	4	2	5	12	3	9	10	5	1	9	18	1	11	5	1	1	9		3	1	2	2	2				2	7
Fire-Pails		2	11		14	16		7	20	14		1	46	2	29			2	1										5	

SPRINKLER SYSTEM

Air Valve No.	1N	2N	3N	3S	5N	5M	5S	7N	7S	8S	9S	9A-W	10-W	10B-E	11N	18E	19E	19W	21M	26N	26S	30E	32W		M.
Air Pressure																									
Water "																									
Valve Sealed																									
Outside Cut Off																									

HOSE HOUSE EQUIPMENT AND INSIDE HOSE

House No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14				Bld'g 12	Bld'g 10		Totals	Pitch Plant A	Pitch Plant B	Pitch Plant C	L. B.	
Lengths Hose	4	4	4	4	4	6	4	4	6	4	0	6	4	14				4	11			2	7	14	6	
Nozzles	1	1	1	1	1	1	1	1	1	1	0	1	1	2				1	1st fl.	3		1	1	2	1	
Axes	1	1	1	1	1	1	1	1	1	1	0	1	1	1				0	2nd fl.	2		1	1	2	1	
Wrenches	4	4	4	4	3	4	4	4	4	3	4	4	1	5				2	3rd fl.	2		1	5	6	3	
Washers	5	5	5	5	5	5	5	5	5	5	5	5	5	5				5	4th fl.	4		5	5	9	5	
Ft. of Rope			50	45				45	45			45	45	50					Noz's	5				50		
Shovels														2										4		
Picks														2										2		
Bars														2										2		
Red. Coupl.				1		1	1				1															
Siam. Conn.					2	2																				

Fire Ladders	S. E. Bld'g 3	S. Bld'g 5	N. Bld'g 19	S. Bld'g 7	S. Bld'g 8	S. W. Bld'g 21	
Conditions							

LANTERNS	
Hose House No. 2	2
" " " 4	2
" " " 6	2
" " " 7	2
F O Gate	8
No. 3 Gate	4
Wrenches	
F O Gate	1
No. 3 Gate	1

No. OF NIGHT MEN	
Foreman	
Watchman	
Laboratory	
Pitch Plant	
Lamp Black	
Mechanical	
No. 6 & 6 C	
No. 12	
No. 14 & 15	
No. 43	
Total	

$1\frac{1}{2}$" INSIDE FIRE HOSE			
5 N E 1 100 ft.		21 S 1 50 ft.	
5 S E 1 100 "		21 N 1 100 "	
6 S 1 50 "		21 E 2 100 "	
6 W 1 100 "		21 N 2 100 "	
6 C S E 100 "		25 A 1 50 "	
6 C S W 100 "		25-2 50 "	
18 S 1 50 "		30-1 50 "	
18 E 2 50 "		30-2 50 "	
19 E 1 50 "		43 E 1 50 "	
19 W 1 100 "		43 W 1 50 "	
19 E 2 50 "		M. O. 600 "	
19 W 2 100 "			
21 E 1 100 "		Total	

PYRENE EXTINGUISHERS			
1-21		30 31	
1-31		30-41	
1-41		30-61	Checked
5A 11		30-32	
6 51		44-11	
6-71		44-21	
19-81			
19-72			
21A 21			Approved
21A 31			
21A 12			
25-32			
30 21			Over

Form 1950

FIG. 1-A

Closet Report	4A	5B	7B	7A	9A		10A	12	13	18		19	19A		20	25A	25		29	30	P.P.		
					1F	2F				1F	2F		M	W			M	W					
Urinals Flush		C															C						
Stools "																							
Condition																							

Fire Door Report	3 3A-B	4 4A	5 5A	6 6A 6B-G	7	8	9 9A	10 10A 10B	11	18	19	21 21A 21B	25	38			
Condition																	

GENERAL INFORMATION	REMARKS
Condition of Outside Fire Hose	
" " Inside " "	
" " Hose Houses	
" " Fire Hydrants	
" " Sprinkler System	
" " Air Valves and Houses	
" " Outside Cut Offs	
" " Fire Buckets	
" " Fire Extinguishers	
" " Fire Doors	
" " Fire Alarms	
" " Sawdust Boxes	
" " Fire Ladder Boxes	
No of Men on Fire-Squad	
Date of last Fire Drill	
Date of last Fire	

FIG. 1-B

otherwise, the pumps operated satisfactorily after they were started.

Can you conceive of a more complete breakdown of management and employees than this, which happened in February? But enough of horrible examples. What can we do to protect ourselves? The answer is plain and does not require a great deal of engineering knowledge, but does require a large amount of common sense, patience and fearless persistence. In the first place your plant must be organized and definite responsibility for the safety of the plant be placed on certain men with a definite line in which this responsibility is delegated in case of sickness or absence. Second, either carry out and enforce their recommendations, or, in case it is not feasible to do so, relieve them of the responsibility by writing them and telling them your reasons for not carrying out their recommendations and definitely assuming the responsibility. It will do much to encourage your inspectors and firemen to know that the company is behind them with dollars as well as with words.

Recently we drew up for our plants a set of instructions and rules, and while we know that these will not fit all cases, and in some cases are a repetition of the Underwriters' rules, they give us at least a working basis and can be amended or added to as the needs may be. One thing we have had in mind was the placing of responsibility for all of our fire protection; second, to make the rules as simple and workable as possible, so that it is easier to do the work right than to do it wrong.

The organization of the plant is as follows:

Master Mechanic in charge. Assistant Master Mechanic when Master Mechanic is absent.

Fire Chief—Assistant Chief Fire Squad.
Inspector.
Pipefitter Foreman—Pipers.
Chief Engineer and Assistants.
Electrician.

Master mechanic, or in case the plant has no master mechanic, plant superintendent should have entire control of and be personally responsible for all fire-fighting equipment. This responsibility cannot be delegated to anyone else except in his absence, when it automatically falls on his assistant.

Fire chief should report to master mechanic and be responsible for the selection of the firemen and their drilling, and at fires he is in command. Master mechanic in case of fire should issue orders through fire chief only. A good arrangement is for the Chief to take charge of the fighting of the fire while master mechanic looks after the laying of reserve lines, salvage of stock, water supply, disposal of city department, etc.

Assistant chief should assume duties of chief in his absence.

Inspector should be chief, assistant chief, or safety engineer of plant. His duties are to make a complete inspection of all fire-fighting equipment once a week and report to master mechanic on form similar to factory A's 1950 (See Fig. 1, A and B), and should issue orders at once for repairs to any equipment not found in satisfactory condition. If these orders cannot be completed the same day as written, special report of same must be made to master mechanic at once.

He should meet all insurance inspectors and take them through the factory, making report at once to master mechanic of the results of the inspector's visit and recommendations.

He should test out all fire hose once a year and make report on each length relative to age, condition, etc. If any hose be found defective he should have same replaced at once.

He should examine all chemical extinguishers and discharge and refill all bottle type of acid-soda carbonate extinguishers once a year. He should see that reserve charges of chemicals for all types are carried on hand at all times.

He should inspect fire doors, rubbish, fire hazards, sprinkler valves, obstructions to sprinklers, valves, hose houses, ladders, etc., and should place the necessary orders relative to this work.

Pipefitter foreman is responsible for all repairs to pipe lines and sprinkler equipment. He must not do any work on pipe lines or sprinkler equipment that necessitates the shutting off of same without obtaining permission from master mechanic's office on form 1407, or an "Underwriters' Red Tag". Where Red Tag system is used instructions on same to be carried out. Where form 1407, Fig. 2, is used the following rules govern: Form to be made out in duplicate, original going to pipefitter, who hangs it in a conspicuous place at his desk and notifies his assistant about same. Copy goes to master mechanic's office, where it is hung in a conspicuous place and the master mechanic's chief clerk and the fire chief or inspector are notified. No one of these five men can leave the plant while form 1407 is up, without reporting to some other person and getting him to assume responsibility for the care of form 1407. In case form is still up at quitting time, master mechanic gets in touch with pipefitter foreman and gets report on work. Pipefitter stays at plant until work is complete.

NATIONAL CARBON COMPANY
Fire System Valve Permit

Mr.................................... Date...................

Permission is hereby given to close valve No.................controlling

....for the purpose of

....

Signed..................................

This valve was closed at............M..............................191....

Signed..................................

This valve was opened at...........M..............................191....

Signed..................................

This valve must not be left closed longer than is necessary. No valve shall be left closed over night unless a special permit for same has been issued, signed by the Master Mechanic or Asst. Master Mechanic and countersigned by the Superintendent.

Form 1407

FIG. 2

Master mechanic can transfer his copy of form 1407 to night foreman, at the same time telling him the condition of work. On completion of work, pipefitter foreman signs his copy and marks in time complete and returns it to master mechanic. When both copies are signed original goes to file and duplicate to inspector, who will inspect the work and report if found defective. When it is necessary to shut off fire protection equip-

ment the following rules must be followed:

Get permit as above.

Valves should be shut by pipefitter doing the work.

Pipefitter must not leave the building for any reason while valve is closed, without written permission from master mechanic. He should not stay at the valve, but where the work is being done.

All pipe and fittings must be prepared and on the job before valve is closed.

Plugs and spacer pieces of proper size to close openings promptly must be ready to be put in place at once if necessary.

When work is complete pipefitter must open valve and report at once to pipefitter foreman, who will inspect work, try valve and return permit to master mechanic.

Pipefitter foreman must see that spare sprinkler heads, extra fittings, etc., are on hand at all times, so that repairs can be made promptly.

Chief engineer and assistant are responsible for the care of fire pump, all steam, suction and discharge lines in engine room and fire cistern or tank. Must try out fire pump once a week, unless same is kept in service at all times. Must not shut off any fire protection equipment without permit on form 1407. In case of fire must report at engine room at once and stand by for service as needed. He must see that duplicate parts for pump, valves, etc., are on hand at all times, so that repairs can be made promptly.

Electrician is responsible for maintenance of all fire alarm equipment. He must not shut off any part of same without permit on form 1407. In case of failure of any part, report of same must be made to master mechanic's office and permit for repair obtained at once. Tests of fire alarms should be made once a week. The best method of making these tests is to have the night watchmen make test at a specified time, notifying engine room before starting tests. Engineer in charge will check calls as they come in and night foreman will make report to master mechanic, who will issue orders for repairs to defective equipment.

General Rules

Inspect all sprinkler systems and check up with insurance company's rules to see if same are installed properly.

Watch for special hazards and see that additional sprinklers are installed if needed.

See that "No Smoking" signs are posted and kept in legible condition.

See that gasoline and other inflammable liquids are kept in proper cans and in as small quantities as possible in buildings.

Look over the plant frequently with reference to fire cutoffs, stairways that would make good flues in case of fire, closed exits, obstructed fire doors, etc.

After a fire see that sprinkler heads are replaced at once and the water turned on as the fire might break out again.

See that some one, preferably the gate man, is instructed to turn in alarm at the nearest city box when your alarm comes in. If you have an electric alarm put a bell in his office with instructions to call the city department when it sounds an alarm. Don't wait for the fire whistle. If you have a fire alarm system *believe it* and get busy with the whistle and city call. Don't try to find out if it is worth while.

Put the covering of your hydrants and the going onto air of your dry pipe system on a tickler for Oct. 15. Remember it takes about two weeks to drain a system and be sure your valve will hold.

Don't uncover hydrants or go onto wet system before April 1st. All dry systems should be inspected hourly at night and twice a day during cold weather. Remember it's a lot better to pump up a leaky line to maintain

the air pressure than to let the water freeze in it.

During extreme weather raise the air pressure on your large systems to city water pressure. It is better to have it too high than run the chance of having the valve trip and freeze up. Keep the handles on your indicator posts at all times or else in convenient boxes under glass where they can be reached at once. Remember that one sprinkler head will put a barrel of water on the floor in three minutes. Don't allow fire hydrants to be used for any purpose except fire during cold weather and be sure when they are covered to see that they are properly drained. Test out several times during the winter by dropping a weight with a string tied to it down the hydrant to see if the barrel is entirely free of water.

List all of your valves which control your fire lines. If you have both right and left hand valves in the plant, mark each valve whether right or left hand on the list and on the valve.

Get in touch with the local fire department and take them through the plant and talk with them relative to the best way of working your squad with theirs in case of fire in the plant.

If you have an independent hydrant system in the yard, a couple of Siamese connections are a very convenient thing to have. If pressure gets low in any part of the yard, couple a steamer to a hydrant and raise your pressure by pumping from the city main.

These are our general rules. In addition to these, our men are supposed to keep posted on the Underwriters' rules for construction. All new work is checked up carefully to see that they are complied with.

One thing relative to fire equipment that is neglected more than any other is the testing of same. How often is the weekly fire pumps test "let go by, owing to rush of work." It is so easy to take a look at it and say, "I guess it's all right, it was a week ago," and that ends it.

In our Cleveland plant we run our fire pump night and day using the hydrant water for washing boilers, flushing sewers, etc. This work runs the pump slowly and at night we open the by-pass just enough to keep it moving, probably 10 strokes a minute —this water going back to the cistern or hot well. On our outside plants ten pumps are run only part of the time but are tried out once a week and a written report sent in.

We inspect all of our equipment once a week. This takes the fire chief's time for nearly two days and his inspection is very thorough. Every piece of equipment is looked over, including sand and water pails, chemical extinguishers, hose, hydrants, ladders, fire pumps, lanterns, belts, rubber coats and boots, sprinkler valves, fire doors and shutters.

In our plant we find that we average about six orders a week for repairs to equipment from this inspection alone.

We used to have considerable trouble from employees using a chemical to extinguish a small fire and then putting the extinguisher back on the hook and not reporting that it had been used. To catch these, we had to lift each one from its hook to see if it was full. Now we tie each extinguisher to the hook with a short piece of string that is easily broken, so if an extinguisher has been taken from the hook for any reason, the broken string gives it away at once. An extinguisher with a broken string is discharged and refilled at the first inspection.

For a plant of say 2000 employees and covering 10 to 20 acres of ground, we have found the following fire department able to meet our need: Fire chief, assistant chief and four squads of four men each, making 18 men in all; in addition to these there are the chief engineer and assistant, who take care of the pumps, and the night foreman and four watchmen who are drilled in handling the equipment.

In the squads we endeavor at all times to have at least one pipefitter and one electrician, preferably two each, and two millwrights and two machinists. The rest of the men must speak English, be physically able to do the work and live within short distance of the plant. We hold fire drills twice a month. The drills are laid out for the entire year, so as to cover the entire plant. The men are assembled at fire headquarters and the signal given on a small whistle, blowing the call the same as the fire whistle does. On reaching the scene of the supposed fire, the chief calls its location and the men go to their respective positions and lay their lines and, if possible, use water on the roof or some place where it will do no harm. If you have not seen it, you have no idea of the muss a bunch of green men will make handling a 2⅝-inch hose with a 90-pound pressure on it, especially if they try to climb a ladder at the same time. If necessary, the drills can be carried out without using water, the men laying the hose and going through the operations up to the point where the water would be turned on. These drills can be held in cold weather and show the men the best places from which the fire may be fought besides training them in handling the equipment. Races between the squads almost invariably develop and these should be encouraged. After each drill the chief and the men talk over the drill and frequently some very good ideas are brought out. So much has been written about training mill squads that it seems useless to try to write something new but all of it falls short of its purpose unless you can get the men who are going to use it interested enough to think about their work and to realize that successful fire-fighting is team work of the highest sort. There is something about a fire that seems to make men loose their heads and forget all that you have drilled into them. I have seen eight men trying to get hold of the nozzle of one hose and all yelling for some one to turn on the water.

Sprinklers

A sprinkler head that works when it is needed is the best fireman there is, and if you will do your part that little fireman of solder and brass up near the ceiling will do his every time. All he wants is water, lots of it, and at from 60 to 80 pounds pressure; getting this water to him is your job. It is not enough to put in the system according to the rules, but you must see that the rules relative to the upkeep are observed.

Recently a fire started in a plant. The sprinkler let go and after a minute or so the water slacked down to just a dribble. Fortunately the fire was extinguished without much loss. Investigation showed that a bunch of scale and pipe cuttings had lodged in a fitting, shutting off the water supply. This, of course, was due to careless workmen, but you can test out your lines with little expense. Shut off the water and drain the system, then take off a sprinkler head at the end of the run and screw a street ell and a valve in place of the sprinkler head. Fill the system with air from the air valve at the dry pipe, then open the valve at the sprinkler head and blow it out. It's a good plan to have a bucket handy for sometimes there is a shot of water left in the line and it comes sudden when there is. By taking off several heads in different parts of the system and trying out in this way, you can be certain that there are no stoppages in the lines. A very frequent cause of no water for sprinklers is closed valves. The Underwriters specify a leather strap and rivet for sealing them. We use ordinary car seals, two or more, sealed together, if necessary, or a short piece of chain fastened with a car seal. We do this for the car seal has a reputation that the strap does not. Small boys and ignorant men have learned that a car seal is to be respected for it guards

a greater value of merchandise and materials than any bank vault, and it guards it not by its strength but by the power that is back of it.

In closing valves for repair or alterations always shut off at the indicator post outside unless there are sectionalizing valves inside the building which will permit of cutting off only part of the system.

When a valve is closed for repairs we believe our practice is better than that recommended by the Underwriters. They recommend that a man be stationed at the valve to open it if needed. We require the man to stay where the work is being done, then if need for using the valve arises, he knows if it is safe to turn the valve on. Opening a valve with a large line broken in case of fire is a serious matter, as it will drain the system of water as fast as the pump can supply it, preventing the use of hose streams from hydrants. It is always a good plan to lay a line of hose into or near a building when the sprinkler system is shut off.

So far you will think the title of this paper is a misnomer—it should have been "Fire Fighting", not "Prevention"; however, the two are so closely tied together that it is almost impossible to separate them. Fire prevention, we have had reams written on, and yet 90 per cent of it can be summed up in two words—"Clean up". Eighty per cent of our fires are caused by carelessness and this carelessness is due to you, Mr. Man on the job, and the sooner you drive the fact home to your foreman and gang bosses that a fire in their department is a disgrace and in many cases a criminal offense, the sooner these spontaneous and unexplained fires will cease. How many of you require a complete fire inspection in each department by the foreman after working hours. You may say it's not part of his job, that he is interested in production and that it's the inspector's job to do it. I will give you a tip; just try this once: Take one of your foremen with you some Sunday morning and go through his department thoroughly, looking for greasy waste, oily rags and overalls thrown on steam pipes, matches loose in drawers, gasoline left in cans, wood and other inflammable materials on the heating system, drop cords wound around gas pipes, gas cocks with loose plugs, rubber hose on gas appliances, oily floors and rubbish in lockers and under benches, and if both you and he do not spend a profitable hour and find many things that you did not dream existed, I would advise you to raise the foreman's wages and watch him like a hawk, for he is a rare bird, namely, "A careful man."

In the rubber factories it has been observed that the number of fires increase during the winter months. This was believed to be due to the increased used of the heating and lighting systems, but while this may have something to do with it, it has been shown that a larger part of the fires have been due to static electricity igniting the highly inflammable solvents and lints. This increase in winter is due, in all probability, to the dryness of the air in the work rooms, for the violence of the static discharge apparently follows the relative humidity of the air. The lower the relative humidity the more violent the discharge. With a relative humidity above 45 the discharges cease. The remedy is to install a recording hygrometer and a humidifier which can be either automatically controlled by a humidistat or by a simple steam jet manually operated.

In many processes the use of inflammable oils and solvents create a fire risk, for these, if the tanks are not larger than 36 square feet surface area, a box of sawdust, to which has been added 1 pound of carbonate of soda to a bushel, suspended over the tanks with the bottom held by a fuse link, is a certain and effective fire fighter. Bins of sawdust and soda with scoop shovel for throwing it on

the fire should be placed near all processes of this sort.

We have one little friend in our fight against fire that is not used as much as it should be and that is the fused link. A little thought will show many places where this link can be used to open drain valves for tanks of oil and gasoline, draining them away to a point of safety, closing fire doors and shutters, shutting down fans; in fact, where any action is required promptly owing to increase in temperature, the fuse link can generally take care of it. On large tanks and especially oil tanks, foamite can be used. A recent report of a tank fire at Port Arthur, Tex., shows that three tanks containing 220,000, 170,000 and 1,200,000 gallons of gasoline, which were ignited by lightning, were extinguished in 20 minutes with a loss in value of one-half of one per cent.

I presume most of you have read descriptions of this system, but possibly a word relative to it may not be out of place. It consists of two supply tanks, one containing foamite 3 per cent, bicarbonate of soda 8 per cent, water 89 per cent. The other containing aluminum sulphate 11 per cent, water 89 per cent. These tanks are connected to a pump and both solutions are pumped at the same time into a steel mixing box that is riveted to the side of the oil tank near the top. The two solutions when mixed together make a stiff foam that flows over the tank and smothers the fire. In one of the tanks which was afire the foam was 6 inches thick.

Our method of fire prevention, that most of us do not think of as a fire protection, is plenty of light in a factory, both day and night. In the day time, by exposing these neglected corners where rubbish, greasy waste, etc., collect, and at night it obviates the necessity of the night watchman's time-honored lantern which no doubt has been to blame for many an unexplained fire; also plenty of light is of more value than many watchmen, for it is a bold firebug who will cross a well-lighted yard with the evidence of his crime on him.

There is one more preventative that does not cost much, except a little thought, and care, namely, "Signs." I feel about these like the old lady when the preacher made a point in his sermon that particularly appealed to her. She jumped up and shouted, "Preach

Fire Prevention

KEEP all Gasoline, Benzine, etc., in Safety Cans.
KEEP all Combustible Material away from Radiators, Steam Pipes, etc.
KEEP Your Part of the Plant Clean.
KEEP all Waste and Rubbish in Safety Cans.
KEEP Ordinary Matches out of the Plant. Use Safety Matches only.
KEEP Cigar and Cigarette Butts out of the Corners.
KEEP open Lights away from Paints, Japans, Gasoline, etc.
KEEP the Doors, Aisles and Windows leading to Fire Escapes clear.
KEEP all Exit Doors unlocked during the time that Building is open to Employees.
KEEP the space around Fire Equipment, Hose Houses and Ladder Boxes free and clear.
KEEP in mind: *First*—The location of the nearest Fire Escape.
Second—The location of the nearest Fire Alarm Box.
Third—The location of the nearest Fire Equipment.
KEEP your Head. In case of Fire do not Scream or Shout. Turn in the Alarm at once. If you cannot find Alarm Box, Telephone.
KEEP YOUR JOB. A BAD FIRE MAY LOSE IT.

FIG. 3

it, pray it, sing it." It was evident that she approved of the stand he took but this was not all. She was not afraid to let everyone know it. If you will look through your plant you will doubtless find many places where gasoline and inflammable oils are used, where a danger sign with the words "Gasoline—Keep Fire Away" would not be out of place. These signs should not only be warning signs but should also give instructions what to do in case of fire. We have posted a sign (see Fig. 3) in many places throughout the factory and believe that they at least give the new man a suggestion that may make him think for a moment or two anyway:

If you post signs relative to fire protection that are orders, see that they are obeyed. Remember that your sign is your order. It is a positive order. If you permit it to be treated lightly, better remove it. It's usefulness is gone and the cause of fire prevention loses one of its most formidable weapons.

Fire prevention commissioners may check some of the large fires, but they have enough to do dealing with the large things. The rank and file of our employees under the leadership of our fire chiefs, inspectors, firemen and foremen must do the bulk of the work if we are to be successful in reducing America's great fire loss. They must act as if life was one continuous Donnybrook fair as far as these little incendiaries are concerned and wherever you see a head hit it.

DISCUSSION

Adam Meyer.—Are the hose that are used the same as the 2½-inch standard hose of the Underwriter's specifications?

J. C. Gillette.—Yes, we use the Standard Underwriter's hose. One important thing in connection with the hose is that the couplings interchange with the local fire department. It is a good plan to get a new coupler, try it with the local department, and then label that *"standard"* and see that every new piece of hose fits to it. It takes but little in the thickness of a thread or a slight increase in diameter to prevent the hose from coupling up, and that is serious in case of fire.

E. P. Roberts.—Your chairman said that when Mr. Gillette started he always wanted to better the proposition. A friend of mine in Philadelphia, who is a specialist in fire protection, got out a little pamphlet, and on the front sheet—will not say who suggested the comment—he put these words: "A wise man avoids fire here and hereafter. We will take care of you here." The hereafter is taken care of by the ten commandments. Mr. Gillette went one better and gave us thirteen commandments. We have taken up co-operation with the city. We found that the captain of the nearest fire house was very much interested. He came over and went around with Mr. Cunningham, Mr. Regal and myself, making suggestions. One thing he wanted was a blueprint framed and hung up in the fire-engine house showing our layout. What he wants to know is where the passageways are which are large enough to take his equipment. He wants the blueprint to show all the entrances to the building, the staircases, and where all the hose connections are. He also wanted us to have a man delegated to be at the gate to notify the city department when they arrive as to where the fire is, and a man has been so delegated. This will save seconds, and possibly minutes, because our plant covers considerable ground. It also brought up the question of keeping open the places marked on the blueprint. It is one thing to have it open on the blueprint, and another thing to have it open when they want to use it. Also a salvage department, which is important and which Mr. Gillette touched on, cutting out motors, taking out stock, if necessary, and protecting from water or fire. On the chart we laid out, which has not been fully developed as yet, we are providing for first

aid. We have a man available for first aid. Where a man is overcome with smoke, or is injured, we will have someone on the job with a safety kit. This is a side issue, but important.

In a plant such as ours, where we have forced blast, and where we run twenty-four hours a day, it is desirable to have a man in each room who knows how to shut off the blast or throw switches. Also we have a good deal of small hose which does not connect to the fire line. Frequently a fire can be put out with small hose or with Pyrene or other extinguishers.

Fire protection includes many things besides fire-fighting, and what is best depends on the situation.

J. C. Gillette.—Relative to the small fire hose. In our Cleveland plant, I think, we have something like a mile of 1½-inch hose scattered in different places throughout the plant. These we connect to the riser on our dry pipe systems so that they are available in case of fire. We have had several cases in which the nightwatchman, or some person in the building, has been able to put out a small fire with the 1½-inch hose. One man cannot handle a 2½-inch hose. He can make a stab at it, but he has his hands full when he has hold of it. He cannot handle it fast. The only place where one man is good at a fire is when it starts and he wants to be right on top of it.

With reference to meeting the fire department at the gate. Our gateman is on duty 24 hours a day, and we have in his office the fire alarm gong which strikes the location of the box so that he knows just where it is in the plant. In addition to that, practically right in the next room, just across a passageway, are sixteen lanterns, and just as soon as the alarm comes in, either he or someone else that is around gets busy and gets these lanterns lighted, that is at night, so that each man coming in from the outside can pick up a lantern as he comes in. This is quite important, because a good deal of time is often lost in stopping to get a lantern lighted in order to get around through the plant.

Speaking of the first aid, we have no special arrangements for that. We have first aid in that a night foreman is instructed in handling it. He is on duty at night. We also have a smoke helmet, which has proved valuable once or twice. It is simply a housing, which slips over the head, and a tube which goes down close to the floor, so that one can get fresh air from the floor. It is quite remarkable the amount of time a man can stay in a smoke-filled building breathing the air right near the floor. I would hardly believe it unless I saw it demonstrated.

J. E. Washburn.—If you were to get your foremen together and make them stand an examination, they would not make 15 per cent in the examination. I saw that once demonstrated. I do not believe anything was mentioned about doors to main outlets opening outward.

J. C. Gillette.—I did not mention that because I thought it was covered under the statement that in all construction work the rules of the National Board of Underwriters are followed. In fact, the building code compels one to have doors opening outward, and also they must be unlocked during the time the building is occupied.

J. E. Washburn.—During the last two or three years the electric dry battery lantern has been very well developed. It would seem to me that it should be used instead of the old oil lantern.

J. C. Gillette.—I saw an instance of the electric lantern being used quite a good deal. It was a year or so ago when we were having our gas-well craze. At night, when nearing the gas sand, one would find electric lanterns hung up in the well house in order to make light to drill by. They kept quite a little bunch of them going that way.

Dr. H. C. Chapin.—Mr. Gillette has emphasized none too strongly the

value of inspection. I recall an unpleasant experience with a hydrant leading from the bottom of a vertical branch, about 4 feet below the main line. When fire broke out we found the vertical pipe so choked with mud as to cut off all flow of water.

J. C. Gillette.—I wonder if anyone present has in connection with his plant a regular fire department in which the men are not working, that is, men which are a special fire squad that is not employed in the plant except as firemen. I would like to hear a little from someone along that line. We have not done that as yet; we have been able to handle our work pretty well with the men scattered around in the various parts of the plant in their daily work. I know at Battle Creek in the Kellogg plant they are pretty well out toward the edge of the city, and they made a proposition to the city that worked out very nicely. They told the city that if they would put a fire department out there and man it, they would supply it and pay half the salaries. In other words, they have the city department practically right in the gateway of their plant. It looks more like a residence than anything else. I happened to have a cousin who is in the department, and I walked by three times before I saw what it was. They are using that scheme in connection with the city to protect their plant, and at the same time protect the buildings and the people around there.

J. B. Clapper.—Did I understand you to say that the members of your fire squad live near your plant so that they are available at night the same as in the day time?

J. C. Gillette.—Yes, all of our men live within three or four squares of the plant, within easy sound of the fire whistle, and we pay them for fire drills and also for calls in the day time. If the fire whistle is blown during the day, the pay on that is one dollar and then a dollar for each hour after the first hour. That is, if the whistle is blown and they get out, and use water, they get a dollar on the fire call. They are paid 50 cents for a drill. At night, in case of a call, it is two dollars for answering the call and a dollar for each hour following. You must make the job worth while for the fellow to roll out of bed at night and get up there in a hurry. The fire chief checks over the men after the fire, and they punch out regular time cards just as they would on work, and these are turned in the next day and the money comes in their pay in the regular manner.

Sometimes it is quite a problem to get the proper men in the fire squad. I do not know of any place where one has to look harder and sometimes use more persuasion to get the right men. There are a lot of men not wanted that like to get in, men who cannot be depended on, men who will be around a little while, and just as soon as the novelty of it wears off it is done for. Also these are the men in executive or foreman positions. I remember one time our fire squad was composed of about two-thirds foremen or gang bosses. The result was that a fire drill pretty nearly wrecked the plant. About half of the departments were shy their foremen or gang bosses. One time we had a fire call just during the noon hour, and I think some of the departments did not get started until 2 p. m. that day. The personnel of the fire department should be watched closely and that depends greatly on the chief. Select the man with the same care used in selecting any foreman; and the combination of chief, inspector and safety engineer in the plant we find works out very nicely. He spends one day looking over the sanitary conditions of the plant, the next reporting on completed work with reference to the safeguards, and then reports on accident cases and makes out the state reports, where it is necessary, and recommendations as to the requirements for guards, etc., interviews the injured men and gets their statements. With a good man on the job it is not a question of

finding work for him. It is a question of doing the work that he finds to be done. I know we find it that way.

A. E. Derby.—Would you mind telling us the equipment you have in your firemen's room?

J. C. Gillette.—In our fire department headquarters, it is almost a joke at present; we have been driven from pillar to post, and at the present time we are using a room in connection with our electricians. They wind armatures in the room, but they keep a passageway open, and around the sides of this room we have rubber hats, boots, pails and wrenches hung up on the hooks, each man having his own location. We keep all of our fire axes, ropes and equipment of that sort in the houses. We have no hose reel, as a good many plants do. Our plant is cut up pretty badly with railroad tracks and other things, and it is almost impossible to handle a hose reel with 500 feet of hose on it to any advantage. In our headquarters it is practically the men's own equipment, which we keep in there.

We used to have a bunch of trouble keeping our fire department's boots. Every time we went out to drill, there would be two or three pairs of boots gone. Finally we painted an 8-inch red band around the boots, just above the ankle. You can see a pair of those boots clear across the plant, and a man is ashamed to wear them. They are so conspicuous that anybody who sees him will look at him, and he gets uneasy right away and goes and puts them back. I do not think we have had a case of boots missing since we put the red band on them. Marking the coats is about the same proposition. The letters "N. C. Co.", or anything of that sort, which may be put on them is all right, but the marks ought to be large enough so that everybody who sees them knows that the article belongs somewhere else and the man has no business with it on. It is just simply a case of psychology, you might call it, if you want to use that word for it. But we find the only way that we can keep our fire equipment where it belongs is to paint it a bright crimson red.

Incidentally another thing we do. All of our extinguishers and small hose racks we back up with a bright red background so that to a man looking around the building for fire equipment, that bright red stands out distinctly from any other color. I do not know where our painter got hold of it, but he certainly has a bright red. I heard one fellow say that our fire equipment jumped right at you every time you came into a building.

Ed. Linders.—I would like to ask if you keep the fire hose in the building or in a building entirely away from the plant?

J. C. Gillette.—I think we have at the present time about 15 hose houses scattered around the plant. In each hose house there is anywhere from four to twelve lengths of hose. These are coupled to the hydrants. And then we have in three or four of the hose houses, which are centrally located, one or two extra lengths of hose that are rolled up so that they can be carried quickly without uncoupling the other hose. In our stock room we carry at all times four lengths of spare hose. They have a standing order that the minute one piece of hose is taken they replace it at once.

Ed. Linders.—How far are these hose houses from the buildings?

J. C. Gillette.—Some of them, unfortunately, are too close. We like to keep the hose houses at least 50 feet away from a building. That is as close as it is safe. Our hose houses were far enough away at one time, but the buildings have crowded in towards them. A hundred feet is better. One is so liable to be driven away from the hydrant that is practically the key to the situation by a shift in the wind in case of a bad fire. It does not pay to put standard hose inside the buildings, although we have one or two places in which we have a fairly high fireproof building with other buildings which are not of so

good construction in the vicinity. We have run up pipes to the fourth floor, and have three or four lengths of hose in those buildings so that they are available to fight from the windows down onto the roofs or across the roofs over the buildings. It simply gives us a little more chance to fight it. I would not recommend placing these in anything but practically fireproof sprinkled buildings.

A. E. DERBY.—Would you explain the system of the fire call covering such a large plant, so as not to have too many signals?

J. C. GILLETTE.—We have a box system. Unfortunately it is not a Gamewell closed circuit system. Our people could not quite see the price of that. We have an open circuit system and the boxes are scattered throughout the plant, and strike the signals with single stroke gongs. One of these gongs is in the fire room, two in the engine room and one in the office. In addition to that there is an ordinary open circuit annunciator on the north wall of the engine room directly underneath the fire whistle, and our plant is divided as follows: On Madison avenue, the section east of our shipping room, the boxes run 11, 12, 13, 14, and so on—that is, beginning with 1. That comes in onto the annunciator board on the same numbers. The signal for that is a long blast with one short blast following it. That signal is repeated three times. All signals are repeated three times. In the section immediately west of that the boxes are numbered in the twenties. The fire whistle for that is a long blast with two short ones. The one west of that is numbered in the thirties, and the forties are the extreme western end of the plant. The lampblack manufactory, which is in the southwestern corner north of the railroad track is in the fifties. The section across the railroad track, pitch plant and factory S, is numbered in the sixties. The signal, however, for the pitch plant and factory S is a little different. The long blast which is given is a half minute long; but on the pitch plant it is three one-minute blasts, and by the time you have blown that big whistle for three minutes everybody in that end of town knows there is a fire. The signal for factory S, which is the storage battery plant, is almost the same, except that instead of blowing three one-minute blasts we blow six half-minute, and we just make a little pause at the end of the half minute. In that way we are able to sectionalize the plant. We tried one time to strike the box numbers. We made three attempts and gave it up in disgust. I remember the first box that came in was 15. One man swore they rang 51, because he missed the first blast and started counting at the fifth; and the next man got it 15, and somebody else got it 23. I do not know how he got that combination. The danger is that a man running to a fire, trying to count the whistles as he is running, does not always start at the same place the whistle did, and he is liable to get some funny combination. So we dropped back to the old system of sectionalizing the plant and using simple calls. If you get within 500 or 600 feet of a fire, 1,000 feet even, it is not hard to locate it if it amounts to anything.

Ed LINDERS.—Why do you notify everybody in the plant? What is gained? I should think it would disorganize the other departments.

J. C. GILLETTE.—The only thing is that our firemen are working through the plant. They are in all parts of the factory. That is one penalty we have to pay, for not having a fire squad that does nothing but look after fire work. If we had our fire squad in a separate fire department, we would probably never blow the whistle. The alarms would come in, and they would take care of it from there. But where the men are scattered all through the plant, we find it necessary to blow the fire whistle.

ED LINDERS.—Could you not get a system that would not arouse everybody in the plant?

J. C. Gillette.—I will tell you what we have in addition to that. We have an auto-call signal that strikes 12 blows. That is also used in connection with the starting and stopping whistle in the morning and evening, and we also punch that auto-call. There is, of course, that interruption of work, but on the other hand it gets your men to the equipment in a hurry, and there is where four-fifths of the value of your fire squad comes. If you do not get your fire out in the first few minutes, you have a big job on your hands. If you need three lines of hose and you have only four men there, that fire is going to get away from you. We try to keep down the fire calls, and instruct our foremen in the different departments to be a little careful about sending in useless calls. We had a case a few days ago over in the pitch plant in which the foreman happened to be on the job. A still broke, the tar ran down into the bottom of the furnace, and the stack was belching forth about 10 or 15 feet out of the top with fire all around the bottom of the still. We had identically the same fire a year ago, and they turned in a fire call on it. But the foreman put his men on it and did a little telephoning, and they held it and did not turn in any call at all. But one must be extremely careful, because some day a fellow may try to fight the fire without turning in the call, with disastrous results.

Geo. J. Cunningham (Philadelphia Rubber Co., Akron, O.).—I visited Mr. Gillette's plant today, and I found it well equipped with fire-fighting apparatus. It is much better equipped than any other factory I have seen. Now, in regard to having firemen scattered through the plant; we have to do that. We must have some way to draw their attention. It has got to be done by a whistle, and in the day time through an auto-call, because that is practically ringing all the time. Of course, we blow the whistle for attention, and then it gives the time call. We have been very fortunate in not having had many bad fires. Of course, we have had a few since I have been there, but they have not been very serious. We have some buildings that are in a pretty bad way in case of fire. Rubber causes quite a heat, and sometimes different stocks will get to burning and cause a bad fire.

A. P. Regal (Philadelphia Rubber Co., Akron, O.).—I would like to take advantage of the occasion to raise three or four questions. One is, it would be of interest to us to know how Mr. Gillette or Mr. Derby cares for both the inside and the outside hose after they have used it for a fire drill or a fire. In our plant I have installed a home-made fire alarm system, open circuit type, for the same reason that Mr. Gillette seems to have installed his—failure of the powers that be to grant sufficient funds for the purchase of a real fire alarm system. In our case, we already had a watchman's clock system installed, and we simply superimposed our fire alarm system on it, using a regular break glass type box, and letting the fire alarm signal come into our engine room on an annunciator. We have an auto-call installed in the plant, and I have designed an automatic ringing box on that, the process of operation of which is that a key is inserted into a hole bearing the number which appears on the annunciator, and is turned. Our auto-call bells all give 20 taps, an interval of quiet intervenes, and then the number is tapped on all auto-call bells, and is repeated four times with sufficiently distinct intervals between. We used the whistle in the early period of the development of this system to sound the fire alarm. We found that to be unsuccessful because the personal element, the man factor, made the signals on the whistle confusing. We, therefore, now sound the whistle but once. Men too far away to hear the auto-call bells run in when they hear that whistle and get the location of the fire from the auto-call bells. You will note that this is diametrically opposite from Mr. Gillette's plan, and

I have not thought over the difference enough to know which is preferable. In drilling our force it has been our custom to send through on the bells in every way the same as a fire alarm, a false signal, letting the men drill to that false signal as a location for the fire. You will note that is opposed to the consensus of opinion brought out tonight regarding disturbing the factory in case of a fire.

E. P. Roberts.—Before Mr. Gillette gets up, I want to mention one thing about the auto-call. Mr. Regal just spoke of the whistle. If you have the auto-call not preceded by the whistle, a man only hears his own auto-call. By having the fire whistle blow, each man knows it is for fire. In our plant the buildings are close together, so there is not much distance to go to a building, and the majority of the men are in the buildings, only a small percentage being outside in the yards.

J. C. Gillette.—Speaking of subconsciously listening to auto-calls. I was down at Akron recently, visiting Mr. White, who used to be with the Baker Electric here. We were going through the plant, and all of a sudden I stopped and found myself counting my own auto-call down there. He began to laugh, and said: "That must be your auto-call." I told him it was. I think if you have tried to strike your box number with your whistle, I sympathize with you, because no man can hurry along and count a whistle trying to blow a signal. But if you will try the scheme of sectionalizing your plant and using the first digit of the box number with your whistle, you will probably be able to work it. I know that has been the only successful whistle we have used. Our foremen in the plant are familiar with that code, and getting the signal from his particular department, as Mr. Chapin says he does, why, he gets up there to see to the care of his equipment. For instance, Mr. Chapin, if it would be 41, would turn over and go to sleep again, it would not worry him at all; but when he gets the pitch plant signal, he gets up there. We find that quite frequently. It brings out the men that you will need in that department at night. In regard to care of the hose. I will ask Mr. Derby to take care of that.

A. E. Derby.—That is all done by the firemen in the warm weather. When we pull out a line of hose, they turn all the water out of it and lay it back straight. We do not lay the hose in coils. It is all laid straight just the same as in a standard fire wagon. In the winter time if we use the hose we have a rack in our furnace department. That runs it up about 25 feet high, and we leave it there to drain and get dry. We see that it gets back again before night.

J. C. Gillette.—You do that with your inside hose, too?

A. E. Derby.—Yes.

J. C. Gillette.—In the summer we make no attempt to dry our standard Underwriter hose. All the boys do is to walk along, carrying the hose over the shoulder, working the water ahead of them so as to be sure the water is all out, and then lay it right in on the racks. The racks are spaced far enough apart so that the cotton dries out easily without any mildewing.

T. B. Hyde.—I think a good deal more has been made of the distraction of workmen's attention due to the fire whistle than is warranted. I have been around different places in the plant and in the past six years the only fire I have seen personally is one that took place in the room where I happened to be at the time. We have had a few fires in that time. We pay no attention to the whistle, either in the office or factory. Neither do the workmen. I might also say that I am sort of a fire-bug. I have answered practically all of the night calls in that time, and I have never gotten up to the plant in time to see a fire at night. I live about a mile from the plant, and it is invariably out by the time I get there.

J. C. Gillette.—In that connec-

tion—I feel like knocking on wood—during the past six years, with the exception of one fire which we had at the pitch plant on which we carry no insurance and that was a tank fire, we have had just one fire in our main factory on which we have made a fire claim. That was in our storage shed about a year and a half ago, in which three or four carloads of baled straw either caught fire from spontaneous combustion or somebody started some fire on some straw that worked down between the corrugated iron on the outside of the building. That is the only fire claim we have made in that time. Incidentally, I do not know what is happening or what we can lay our good luck to, but we have not had a fire alarm turned in for almost seven months now. Ordinarily we average a fire call every month.

T. B. Hyde.—Won't you elaborate a little more on that fire call and tell us the advantage of a fire pump as a fire alarm?

J. C. Gillette.—Our fire pump at night just barely keeps moving. Of course, at night the only thing running is the rotary, and that morning—it was at four o'clock in the morning—all of a sudden the engineer heard that pump chuck, chuck, chuck, chuck. He jumped right up and immediately ran over to it and stood there and listened. He did not know what was wrong, but he knew something was happening. He threw the lever over on the by-pass, so as to give her full steam, and hollered to the other men to stand by the boilers and shake things up. It was practically a minute and a half or two minutes afterwards before the alarm was given by a milk man passing on the outside of that building. The sprinklers had let go and started the fire pump; the milk man going down the street saw the smoke rolling out of the building and swung around the corner and turned in the alarm. I think that was the first time I ever heard of a fire pump sending in its own alarm.

Speaking about getting in touch with the local firemen. Chief Speddy and his men come up to our plant frequently and go through it, go around looking over conditions. If a road is blocked, as has been the case in the last year at different parts of the plant, I notify him personally. For instance, when Madison avenue was torn up, there were only certain approaches where they could get into the factory. When Berea road was cut up with a sewer there were certain places he could come through to get to the pitch plant. I kept him in touch with those. We have a steamer hydrant over at the pitch plant that draws from the pond over there, and they have tested out several of their new equipments, testing out for suction. Frequently they have a minor case of trouble on one of their engines. They will run up to our plant, and we will help them out with it in order to save them a trip down town to some of the shops or something of that kind. Maybe a thread on a coupling is a little crooked or something of that sort. It does not amount to anything, what we do, but it keeps the equipment in our neighborhood, which is a whole lot better than having it in a shop down town or something of that sort. By working with them that way, you get in touch with them, and in case of fire you can get them to listen to your instructions. Now, you know more about your plant than the fire chief does; that is, the outside fire chief. At some places in our plant, throwing water into the fire would be about as disastrous a thing as you could do; and some chiefs, when there is a fire and anybody starts telling them anything, will say: "Go back and sit down, I am running this fire." We do not have any trouble of that sort with the Lakewood department. When they swing up there, I frequently meet them. In that way we are able to handle the things a whole lot better.

I remember a very amusing thing that happened. It was amusing, but it was also disastrous. It was at a plant my brother was in charge of

down at Fort Smith, Arkansas. They use natural gas, but during the winter they shift over to oil burners. They have a gas holder which they use for oil storage. Somebody without much thought of results had put the big water tank about 10 or 15 feet from this gas holder, a steel tower with a large tank on top. The lightning or something started the oil in this tank. The chief engineer immediately opened the drain valves and started the pumps going pumping to the outlying tanks and draining the big tank over into the sludge pond. The local fire departments came up, and in spite of all they could do insisted on throwing water into the oil. The result was the water went to the bottom, and the oil stayed on top and burned. The fire got away from them. It got pretty hot, and the wind shifted so it blew the flame over on the legs of the water tower, softened the steel work, and the tank turned over and went into the midst of the gas holder. Everybody ran. The thing just simply wiped up about a half mile of houses, sheds and outbuildings between there and the Arkansas river. The houses which were destroyed were no great loss to the city or the community, fortunately.

M. F. LOOMIS.—I might mention a device that we have developed along this line. In every machine shop back of the benches where there is erecting going on there is always a little gasoline necessary to rinse off the pieces being assembled. We could not find anything on the market that was satisfactory for that work, so we made the patterns and built cast iron pots about 14 inches high and 12-inch opening, on the side of which is a foot lever. Pushing down the foot lever raises the cover. The cover fits down so that it is not handy to lift it unless the foot lever is down. When the foot is removed the lever falls to place. The cover fits in such a manner that water poured over the pot would not enter it and displace the gasoline.

Have you ever had any experience in the use of air slacked lime for gasoline fires?

J. C. GILLETTE.—No, we have not.

M. F. LOOMIS.—In a plant that I had charge of for seven years, we came to the use of air slacked lime for extinguishing gasoline fires. We built several engines a day and gasoline was used for washing them after testing. Occasionally this gasoline would become ignited and a fire would result. We found pails of air-slacked lime very effective. The lime does not deteriorate at all, but remains in a light, fluffy condition; and whenever one of those engines took fire, generally one pail of lime thrown into the air above the engine would put out the fire, although the car and engine would be thoroughly saturated with gasoline. I do not think we ever used more than two pails.

J. C. GILLETTE.—That is a new one on me. On most of that work we have a square box, about 2 feet square, holding about four bushels of sawdust, and then on that we have a big scoop with a long handle. That fits into a pocket right at the bottom, and a clamp holds the handle up in shape. If you pull the shovel out, the door at the bottom opens automatically and gives you a chance to shove your scoop in and throw about a half bushel at a time with that big scoop. We have found that has been very effectual, especially with tank fires. For instance we have a good many pans of hot paraffin and the sawdust just floats out over the top and practically shuts off the air from the oil. We have found those very good. Another proposition we have installed over our pans is just a square metal box holding four or five bushels of sawdust, depending on the size of it, with the bottom of it hinged at the sides and lapping at the center. Those are held together with a fuse link. Just the minute that fuse link lets go, the sawdust drops onto it and spreads over the whole thing. And while we have not had an occasion where one of those have opened up, in our test

proposition it worked out very nicely. The thing which we find the hardest to look after and to take care of is fire-fighting equipment in cold weather. It drives the chemical extinguishers in from the outlying cheap buildings, which are the biggest fire risk. It puts a severe condition on the dry pipe system, which must be watched very closely, and it makes the care a whole lot heavier. There is one thing we do. We have had occasion once or twice to shut off the sprinkler system in the building over night. In a case of this sort we have always put on an extra watchman, and we do not station him at the valve, but he has to make the rounds of that building all night long, just going from one floor to the other every so often, and down again. When we put him on, we instruct him what to do in case he finds fire anywhere, in regard to opening the valve. And we do that feeling that it is a worth-while investment. You may think it is worth while to take a chance, but the way we look at it, the sprinkler system was put in, and it cost you considerable money, your sprinkler system is out of service, and in order to get that service the man's wages do not run so very much over the interest on the investment you have already put in to protect the building; and we feel that it is necessary, in case your sprinkler system is off, to have a watchman in the building all the time. Of course, during the day when the regular employes are in the building, we have a pipefitter there working on the job, who is responsible. We have never had an occasion where we have had the system shut off during the day in which we were not working on it. We had a case last winter in which a dry pipe valve let go, and a 6-inch main froze. That is a pretty good-sized job to thaw, and we cleared it up in about an hour. It was above ground, and it was where we could use a big gasoline blast torch on it, and that cleared us up in short order. If it had been in the building, we would have had to slap live steam to the outside to thaw it out. One thing that I am always afraid of is that with the dry pipe system in and the building down below freezing, and the pipes full of frost, it does not take many minutes, in case the valve drips, to plug the whole system with little pockets of ice; and that is one reason why we advocate the raising of the pressure on large systems, especially if they are exposed in extremely cold weather. You know if the pipes are full of air at 60 or 70 pounds pressure, there is not very much water going to flow up hill against it.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUG. 24, 1912.

Of the Journal of the Cleveland Engineering Society, published bi-monthly, at Cleveland, O., for Oct. 1, 1917, state of Ohio, county of Cuyahoga. Before me, a Notary Public in and for the State and county aforesaid, personally appeared G. S. Black, who, having been duly sworn according to law, deposes and says that he is the Business Manager of the Journal of The Cleveland Engineering Society, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of Aug. 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit: 1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, The Cleveland Engineering Society, 310 Chambers of Commerce Bldg., Cleveland. Editor, Publication Committee, E. S. Carman, chairman, 310 Chamber of Commerce Bldg. Managing Editor, None. Business Manager, G. S. Black, 310 Chamber of Commerce Bldg. 2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.) The Cleveland Engineering Society, 310 Chamber of Commerce Bldg., composed of 1200 members. President, J. H. Herron, 2041 E. 3d street, Cleveland, O.; vice president, E. B. Thomas, 619 Guardian Bldg., Cleveland, O.; secretary, H. M. Wilson, 1250 Rockefeller Bldg., Cleveland, O.; treasurer, C. E. Drayer, 512 Columbia Bldg., Cleveland, O. 3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None. 4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him. 5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is. (This information is required from daily publications only.)

G. S. Black, Business Manager.

Sworn to and subscribed before me this 1st day of October, 1917.

(Seal) A. J. Miller, Notary Public.

(My commission expires April 26, 1918.)

Our Merchant Marine, Present and Future

By Capt. Irving L. Evans*

Paper presented Sept. 8, 1917.

Index No. 623.8

I have been asked to talk here tonight, not because I am a public speaker, but because you are interested in what the United States Government, through the Shipping Board with which I am connected is doing toward manning the American Merchant Marine. I could tell you in a few words all that we are doing. If I were to attempt to tell you the far-reaching effect of that work, I would consume much of your time.

At the outset, I might say that the demand for this work has been brought about by reason of the shortage of men qualified to man our merchant vessels as officers. That applies to both engineers and navigators. The shortage exists at present only in the lower grades. The woods are full of masters and mates and chief engineers. Few of them care to sail unless they are masters or chief engineers; but unfortunately we need a few other men on the boat to help run it.

To give you some idea of the needs of the service, I might say that at the present time there are in the United States approximately 30,000 licensed steam engineers. Of that number a great many have a limited license ranging all the way from ten tons up. When we eliminate those who have a limited tonnage or who are licensed to sail on river boats only, or on lake vessels only, or inland waters, those who have gotten beyond the age where they can be of service, particularly in the war zone, those who are physically unfit for duty and the large number who will be found working on shore in industrial plants of various kinds, there is a very small number left in the actual sea service. It is because of these things, these conditions, that the government has taken the steps it has.

I had taken no part in any of this work until I received a telegram asking me to make suggestions about the manning of the proposed wooden fleet. We have since that time had much controversy about whether we should have a wooden fleet or a steel one. The merits of the controversy I do not care to touch upon. I believe, however, that we will have a merchant marine eliminating largely the wooden vessels.

I might touch briefly on our merchant marine as it existed in the early days. It was in 1789, I believe, that the first Act of Congress was passed to give any encouragement to the merchant marine. When the first tariff law was passed, about 23.8 per cent of the imports and exports of this country were carried in American bottoms. For the next forty years, an average of 90 per cent of the foreign commerce was carried in American vessels. In 1826, 92.5 per cent of the American commerce, both exports and imports, was carried in American vessels. That was the year in which the highest percentage was reached.

The year previous to that, Daniel Webster, in a pardonable flow of oratory and pride, made the statement that our navies accepted law from no foreign sovereign. He did not realize what our merchant marine would be in 1915. At that time, according to the records which we have, the actual American tonnage engaged in foreign trade was less than one million. Combining all the vessels

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in the United States, including the Great Lakes, river traffic and inland traffic of every kind, as well as the foreign trade, there were only about eight million tons. You can therefore understand how, at the outbreak of the present war, the demand upon our merchant marine was overtaxed.

With this condition existing, it was necessary to take some corrective measures. The government had, prior to that time, begun to realize the need for a merchant marine. After much consideration and thought upon the subject, the administration decided upon the Shipping Board as a solution of the problem. An Act of Congress created the Board, the President appointed its members and they began work. Not as much has been accomplished as we might desire, yet considerable has been done. When we consider the difficulties that have been thrown in the way of the government by meeting the present crisis, we can appreciate why more has not been done.

We will look first at why we are in the war to see the difficulties. It was because Germany undertook to say to us that one day each week we could send a ship to Falmouth. We replied that six days in each week the kaiser could go to hell. History will record that the United States was driven into the war to avoid unspeakable shame and to help make the world safe for democracy.

If I were to touch upon the question of commerce and the effect of the merchant marine upon it to you gentlemen who are engaged in all branches of industries, all branches of engineering, with your knowledge gained through scientific magazines and other sources of information, I would feel the way I did the first day I stepped on board the deck of a ship as an apprentice boy. That was at the port of Baltimore. The impressions I received on that occasion have remained with me ever since. There on the main hatch sat an old sailor splicing a rope, near by was another splicing a wire, and still another sewing canvas. Forward there was an officer giving orders to some men who were preparing the ship for sea. On the quarter deck was the captain pacing back and forth, a navigator of the old school impatiently waiting the sailing hour when he could be once more upon the high seas, the only place where he was happy. I quickly realized that I was a stranger there, an apprentice among masters. That is my feeling when I attempt to refer to the question of commerce before you gentlemen. Briefly, however, I shall touch upon it in order to point out the necessity for the work in which we are engaged.

You all know doubtless that the value of the exports of the United States, and also the imports, has greatly increased in value and volume within the past few years, but the amount of that commerce carried in American bottoms has decreased. When this war is over, if we go that far first, there will be a spreading out in every direction of vessels of the different countries seeking their share of the world's commerce. If we are not at that time in a position to get and hold our share of the commerce, we will find conditions in this country far worse than they were just before the outbreak of the present war. That will be due to the fact, in my opinion, that the manufacturing industries in this country have developed to such an extent that the present output is sufficient to supply the demand in six months for the whole year. This is for home consumption. If then, the factories are to be kept in operation, the mills kept going and labor employed, we must find foreign markets for our manufactured goods.

Our foreign commerce up to the time of this war has been largely natural products which were necessary to the life and industries of the great maritime nations. Those products

were carried at a reasonable freight rate because the consumers, the purchasers, paid that freight. They were carried principally in the vessels of the countries which needed these supplies.

When we come to place commodities upon the market, however, which are of a competitive nature, we find a different situation. We will then find, as we have in the past, that we are discriminated against with high freight rates, with bonuses paid to the ship owners of the foreign countries, by the nation of the ship's flag, for goods exported and imported in British ships, German ships or those of any other nation. The rule was practically the same everywhere except the United States. That is the condition then which we will face.

We will have to have organizations in these various countries through which the banking arrangements can be made for the sale of goods. For example, I can recall one specific case of a deal in South America where a large Chicago manufacturer, after considerable effort, secured a contract to furnish goods. He went into a bank to have the contract guaranteed. He was informed that he could not get a guarantee on any contract except for foreign goods, none on American contracts. He had to go back to the company with which he had contracted and beg to be released from his agreement. These are all conditions which enter into this great problem and which will have to be met in order to give a market for the manufacturing industries of this country after the war.

What relation has the merchant marine to the present emergency? Gentlemen, I am confident that there is no part of the government service, there is no branch of the service, whether it be military, naval or otherwise, which is more important today than the merchant marine. Without the merchant marine, our armies, no matter how large they may be, how strong, how well equipped nor how brave, would be of no assistance in this war if we have not a properly manned and equipped merchant marine. The merchant marine will furnish the sole line of communication between this country and the battlefields of Europe.

The figures, I believe, as given by the war department and other branches of the government, according to their latest estimates, are, that about fifteen tons of shipping will be required for every soldier placed in Europe. There has been talk of our having a million and a half troops in France by spring. We will assume that we will have a million there. That means that we shall have to have in operation at that time in order to maintain that force of men in Europe fifteen million tons of American shipping in constant operation. We cannot place one man in Europe as a soldier for whom the fifteen tons of shipping has not been provided. If that shipping is not kept in operation that army in Europe, as well as the armies of our allies would be helpless. You can, therefore, appreciate the necessity for the properly manned and equipped merchant marine. You can see its relation to the present war. It is the manning of these ships, the overcoming of the present shortage of officers with which I am particularly engaged.

In that connection I might give you some idea of the number of men required on each ship. First, these ships, we will say, average from five thousand to seventy-five hundred gross tons. Ships of that class here on the Great Lakes where you gentlemen are acquainted under the present law, are required to carry from thirty to thirty-two men. Ships sailing under the Canadian flag right over the same route over which the American ships travel, ships of the same size and type, are manned and some of them sailed by men who have sailed American ships—I will take for example

one of their largest and one of our largest—where we have about thirty-two men they carry eighteen. Our ships can be operated with fewer men. The reason they are not is due to our present navigation laws. There is where we need some sane legislation. Unless we have a complete revision of our navigation laws we cannot hope for a very long continued and successful merchant marine. With the building that is now going on, with the ships which we already have, and the contracts which are let for the construction of ships, the rate at which the shipping of the foreign countries has been destroyed will undoubtedly leave this country with the largest merchant marine in the world at the conclusion of the present war if it lasts beyond another year.

In view of these facts and these conditions, you gentlemen are interested, not only in having a merchant marine through which the industries with which you are connected and associated can find a market for their goods, but you are at the same time interested in having navigation laws under which a merchant marine can be established and kept in existence.

In that connection I might say that legislation on that subject must by the nature of things come from the Middle West. Congress is controlled by the inland states. The people of the Middle West must become interested in the subject of the merchant marine to such an extent that they will elect men and send them to congress who can see the needs of the country, the needs of the men, and the factories here in the Middle West, the industries with which you are connected and associated. Until that time, we can hardly hope for a successful merchant marine, even though we have the largest in the world at the conclusion of the war.

Now, for the purpose of training men to man these ships which are being turned out at a very rapid rate at the present time, the Shipping Board, through its recruiting service, has established in the United States, thirty navigation schools where men are taught the science of navigation. There are seven engineering schools throughout the United States where marine steam engineering is taught. There are four navigation schools on the Great Lakes and two engineering schools. The men who are qualified to enter these schools must be men who have had the experience required by the rules and regulations of the steamboat inspection service, for a man to become eligible to obtain a license as an officer on a ship. It would be useless for us to take into these schools any man who has not had that experience. The war would be over before we could give him his sea experience and then train him as an officer. We therefore have to take the men who are qualified by experience to become officers, and give them the technical training which will enable them to pass the examination of the United States steamboat inspection service and obtain a license. We have to take sailors who have become accustomed to the trade and business which they have followed. We have to begin, as it were, with a sort of finished product, and just give it the rounding touches in the way of giving him the technical knowledge to qualify him as an officer.

The schools at present are turning out men a little faster than they are needed, but beginning early in 1918, ships will be launched and going into commission at a greatly increased rate. Before spring the rate of production will be more than doubled. You can therefore appreciate the great demand there will be for men of the class in which there is already a shortage in the lower grades. Here on the Great Lakes there are thousands of men engaged in the trade, many of whom are ready and willing to go to the ocean to serve their

country. Great care is being taken, however, by the government not to interrupt in any way the operation of the ships on the Great Lakes, because they are just as important in the present emergency as the trans-Atlantic ships. Iron ore must be brought down to the furnaces, grain brought from the Northwest on its way to the seacoast, coal carried back to keep the mines and the industries of the northwestern section of the country going.

For the purpose of handling the subject in hand intelligently the government started several months ago to make a complete census of every licensed man in the United States to ascertain his present occupation and whether he is available for service either on the Great Lakes, the ocean or elsewhere. Every man is being written a letter inquiring along that line and asking whether he is willing to serve. There are thousands of men who have given up their former occupation—and by this I mean licensed men. We are preparing to get those men back to the sea and lakes, and, if necessary, to say to the man who is qualified for salt water service, that he must go there and serve; to say to the man who is ashore here in Cleveland for instance, that he must go and take a vessel on the Great Lakes and relieve the man who is qualified for service at sea, and thus distribute the men where they are most needed.

These are the steps and the precautions which are being taken by the government at this time, and I might say that the big part of the work of getting up the census of these men is being done by the United States steamboat inspection service. They have the records, the card indexes, the filing system and information from which they can give the desired facts in the shortest possible time. That information is almost complete. Many of the men have already been communicated with and are in line for this sort of work.

Now, in connection with the manning of these ships, and after they are manned, comes the question of operation. By whom are all these ships going to be operated? In this connection I am going to touch upon a subject about which you have probably seen little comment and heard little. I have already called your attention to the fact that it was after due consideration by the administration that the Shipping Board was formed to give governmental support to the merchant marine for the purpose of building it up. That subject, since we have gotten into the war, has taken a different aspect. The Navy Department at the present time is seeking to get hold of the management of the merchant ships of this country. The reason they give for that is the labor situation principally, arguing that unless the ships are manned by the military forces of this country, the men on them subjected to military rule and discipline, that great line of communication may in a day be broken by a strike. The argument is plausible; it sounds reasonable. I will say that personally I am for that plan of operation which is the most beneficial to this government and to the forces, to the brave men of this country who are in Europe and who will be placed there.

The seaman has never been a slacker. History records that in every period of danger to the nation he has come valiantly to the aid of his country. It is my opinoin that the sailors of today will do the same. There is no more patriotic body of men living than the sailors.

In this connection, if you will permit me, I will illustrate by reciting an incident which I witnessed as a young man at sea. I was on the sailing ship "T. F. Oakes". We were bound from China to New York with a load of tea and matting. We rounded Cape Horn in a snow storm, and had not seen land in three months.

We had not seen a ship of any nationality in thirty days. One morning just about eight bells, I was on duty at the wheel when the look-out reported a ship off the weather-bow. As the ship drew near—and our new-found friend was a sailing ship the same as ours—the men were all on deck with as much enthusiasm and expectation about the nationality of our new-found friend as you would feel about the next act at some theatrical performance. It was something new and different to break the long monotony to see a ship at sea. As the ships approached each other the flag of each was hoisted to the peak and unrolled, and when they were abreast of each other, the halyard was pulled and on each the stars and stripes rolled out to the wind. There was not a word spoken but on our ship, just as though an order had been given, each man, from the captain down to the cabin boy, took off his hat to the American flag. That, gentlemen, is an impression of the American sailor which has remained with me ever since. That is the spirit, I believe, of the American seaman today.

That is not the whole answer to the contention of the naval men, however; and as I have already stated, I wish to see that plan adopted which is the best for the country. I have, however, an interest in the future of our merchant marine, an interest in the future of our home industries, an interest in creating a market for the manufactured products of this nation.

If we place a merchant marine, which promises to be the largest in the world, at the conclusion of the war, under naval operation, manned by the naval reserve, as they propose to do, we will have a merchant marine manned by a large percentage of college men, a large percentage of inexperienced seamen, all under military rule. The present experienced seamen will seek other occupations, being replaced by these inexperienced men, so that when the war is over the navy will step down and out and turn back to the civil authorities the operation of the merchant marine, the largest in the world. We will then be called upon to man those ships, to train those men, give them the experience, build up our personnel from officers down to the cabin boy, and build up our executive operating force on shore.

Gentlemen, I believe—I may be wrong—but I believe that the best plan is to let the merchant marine be operated through some body, whether it be the Shipping Board or a commission appointed for that purpose, having as a personnel of the body naval men and our best shipping men. Let it be operated by such a body that when the war is over we will have a personnel of officers and men trained and ready to operate that fleet and get our share of the world's commerce and hold it.

In conclusion, gentlemen, I want to say just one thing; that these men who have followed the sea for life, or followed it for a livelihood, a profession, trade or occupation, whatever we may call it, are, I am sure, going to meet the present emergency just as they have met emergencies in the past. I am sure that every man or the majority at least, and the large majority, will follow and enter into this work feeling just as Mr. Lincoln did on his first trip to Washington. When his train stopped at a little way station, a man, representative of the now-firm-minded and determined citizens, got upon the train and said, "What are you going to do, Mr. Lincoln, when you get to Washington?" The President lifted up his long hand, reached down and took hold of the American flag with which his car was decorated, and said, "By the help of the Almighty God and by the support of the truthful and patriotic citizens of this country, I propose to uphold and defend the Stars and Stripes." Our President is following the steps of his great predecessor.

You, gentlemen, through your interest in this great subject, through giving publicity to the matter, impressing upon the public the work done by the government in these schools in whatever way you can, and by showing to these men of the sea that the country appreciates what they are doing, what they have done, and what they will do, you can greatly help the cause.

I do not know whether we shall ever come to the point where we will have to call upon an organization such as yours for the young men who have been trained in the technical schools to come forward in large numbers and take up this work of marine steam engineering. If it comes to that point, I am confident that if a call were sent out, no more ready response could be found than among the class of men representative of your organization. Many of the men who have been trained in technical schools as mechanical engineers, can qualify at once to become steam engineers. They could be sent aboard a ship and could successfully operate the engines. With the great number of experienced men whom we have placed in charge of those vessels and their engines, and these young men placed under them and working with them, great results could be obtained, so that if it should come to that point, no doubt you will have a call from the Federal Government, and I know that there will be a ready response.

In closing, gentlemen, I .want to say that I hope and I believe that you will agree with me in this: that the time is not far distant when the American flag will be seen daily in some part of every nation whose shores are washed by the salt sea.

DISCUSSION

W. J. Oettinger.—In case the government did send out a call, would the engineer's society distribute papers as they did for the engineering reserve, so as to get the qualifications of the men, and find out what they were best fitted for?

J. H. Herron.—The Engineering Society would probably do that in any way that the government might suggest.

Capt. Irving L. Evans.—Right in that connection I might say that I have received instructions only this week from the East that if I know of any mechanical engineers or men of any class who are qualified to become engineers within a reasonable time, who want to be placed in sea service to qualify them to take a license, that I should notify the East and arrangements will be made to place them and give them the opportunity. So that if there are any young men whom any of you know, any mechanical engineers or others who could, by a short period of training, be qualified to become officers, the government will take steps to place those men where they can learn the business and get their licenses and become officers on these ships.

Ernest Hollings.—There is just one point in connection with the engineering side. In the old country, about half the engineers who operate the electric light stations, etc., have been sea-going engineers. So, just reversing the point, there is, so to speak, a big reservoir of engineering talent that is available because the problems are very much the same, running the engines or electric light stations or power production, to what they are on board the ships.

J. H. Herron.—As the last speaker has said, especially in Scotland, nearly all the engineers are trained primarily as naval engineers and take service afterward in industrial plants. We have here quite the reverse. We have comparatively few of our engineers trained as naval engineers, but principally as stationary engineers.

Has the government made a study in any way of qualified engineers who might be taken from industrial

service and with some training be put into the merchant marine service?

CAPT. IRVING L. EVANS.—The government is making this census of all the licensed marine engineers. There are a great many applications from the stationary engineers and some from the mechanical engineers, but the largest number of men coming from the industrial plants are the stationary engineers. We get quite a good many of those and some very excellent men.

I might say in this connection that I do not believe the problem of meeting this situation, so far as engineering is concerned, will be so acute as it is with relation to navigating officers. It may come to the point where the ships will have to be manned by only one or possibly two navigators, and the others be merely officers with sufficient experience to qualify as bridge officers, letting the bridge officers run the ship and keep the lookout, and especially for submarines, while the other fellows do the navigating. That plan, however, under our present laws, cannot be enforced. Every man at least from the third mate up—and that is the lowest rate of license that can be obtained—must be a navigator. The third mate does not have to know as much as the second or first mate. From the second mate up, the examination for all the rest, to and including the master, are substantially the same, that is, they require knowledge of navigation. So it is my opinion, from the present situation, that the engineering problem will be more easily solved than that of the navigation officers.

J. H. HERRON.—How could the civil or the mechanical engineer work in as a navigating officer? What are the peculiar requirements, you might say, for the navigating officer?

CAPT. IRVING L. EVANS.—The navigator has to be able to find his position by astronomical observation, and he is required under the rules and regulations, which have the force and effect of law, to be able to find his position by the sun and the stars. The old theory of finding it by the moon has become somewhat obsolete and is no longer required by the rules and regulations.

The men whom we have had teaching in the schools, that is, in the navigation schools, thus far, have been the teachers from the large institutions, who have had the subject of astronomy. In Case School of Applied Science here in Cleveland, Doctor Wilson has had charge of the instruction for the navigation school. In connection with the practical part of the instruction we have a sea captain go around and deliver lectures covering the remainder of the subjects upon which the men will be examined; such as the storage of cargo, the international code of signals, the rules for preventing collision at sea, the use of the life-line and gun, seamanship and a number of other subjects on which a man must be examined.

Now in the engineering schools we have men in charge who were at the head of the mechanical department of instructions where the schools are located. For instance, here in Cleveland it is located at Case School of Applied Science, and one of your members, Professor Vose, is in charge of the class. And in that connection I wish to say that while I do not understand all the engineering problems, I have been informed by some who have passed through his classes—and I do not know whether it is because he had impressed upon them that he knew more than they did, or whether it was because they did not know much—that they said it was a very good course he was giving. Mr. Hunter, of the United States Steamboat Inspection Service, who is a veteran lake engineer, and who examines these men after Professor Vose has gotten through with them, I believe, has indicated that he thinks it is a pretty good course for

the men to take before they come up to see him. Mr. Hunter does not let them stop, however, with the theoretical side of it, or the mathematical problems; he puts on his overalls and starts up the little engine he has there for exhibition and makes them adjust and set the valves—I think that is what engineers call it—and do other things of that kind to prove to him that they are practical engineers as well as theoretical.

But we are obtaining excellent results from the instruction being given in the schools. We have had some lectures given to the men by practical engineers, and I do not mean that Professor Vose is impractical when I say that, but by steam engineers who have been accustomed to operating and repairing the engines and meeting the problems and other conditions which he confronts while in the engine room and explaining these things to the men. That work has been given in the engineering schools to some extent in connection with the other work.

C. T. Harris.—Captain Evans, you referred in passing to the necessity of some modification in our present navigation laws if we maintain a permanent maritime service, but you did not develop that point. I do not know whether you feel at liberty to tell us what some of those modifications are and whether congress has made any move in that direction.

Capt. Irving L. Evans.—Congress has not taken any steps, I believe, toward the modification of our laws. The men here on the lakes were permitted to operate their ships with fewer men—not so few as some of the Canadian boats have operated with, as I have indicated, but with fewer men than at the present time, the number with which they have heretofore successfully operated—I believe that large numbers of men could be released for the trans-atlantic merchant marine. But going further with this question of a revision of our navigation laws, I should dislike to attempt, at this time, to point out the necessary modifications. We would practically have to start over, and anyone who makes a thorough study of those laws will realize and appreciate that. That will come, I believe, as the result of the awakening of the American people, and especially the Middle West, to the need and command for the merchant marine. Few of you men, and few of the American people, especially away from the sea coast, thought or cared whether we had a merchant marine or not prior to the present emergency.

That, gentlemen, is the reason and the only reason, in my opinion, that we have not had a merchant marine; and as I have already indicated to you, we cannot get a modification of the navigation laws without the backing and co-operation of the people in the Middle West. They are the sea-lords, as it were. They hold the whip hand in this situation. There is no denying that fact; so that if any relief comes it must come through the work of the people throughout this section of the country; and that thing should be brought to the notice of the public by you people at every opportunity. And that is the one thought I would like to impress upou you, the need for the merchant marine, because it is vital to your manufacturing industries, to your continued employment and to the employment of the men who work under you. Without that we will find after this war, bread lines and soup houses more numerous than they were shortly prior to the war. I shall not attempt to say whether all that shall be brought about by a tariff act, by a ship subsidy, or some other means. There are dozens of ways it may be done.

I was foolish enough at one time to write a number of articles on the question of why we should have a merchant marine. That was quite a few years ago. I saw that it was

hopeless at that time, and became discouraged and gave it up. Since this new situation, this new emergency arose, I have gotten back into the thing, and I am sort of working up the old enthusiasm again. I have heretofore, since I have been in this work, spoken a few times on this subject, but my remarks have always been of a sort of rambling nature as they have been tonight. However, I am becoming deeply enough interested to begin to classify my thoughts so that I can give them logically hereafter.

E. H. LOUGHRIDGE.—If the naval authorities take charge of the merchant marine, will it be necessary that they should let loose at the end of the war? Could they not continue to run it?

CAPT. IRVING L. EVANS.—The men whom they have enlisted in the naval reserve by which they propose to man these ships, are enlisted for the period of the war. When war ends those men have a right to go ashore, they cannot hold them beyond that period as a matter of right. The statement of one naval officer—I won't be certain whether he said, "Of the men we have enlisted 75 per cent are college men," or whether he said, "Seventy-five per cent of those enlisted and qualified to become officers are college men." It was one of the two statements, I cannot recall which, but a very large percentage of those men are college graduates. You can therefore realize that we will never have, as much as I would like to see it, a merchant marine manned by college graduates. It would certainly put it on a very high standard; but we will never have it because they are not going to get down and continue to do the things that the average engineer is called upon to do in his engine room. They are not going to work like the old fellows here, like Mr. Hunter and some of the rest of them who have gone through that school. They are going to find an easier way to earn their dollars.

R. M. MORGAN.—I would like to ask Captain Evans what will be the plan of the merchant marine at the end of the war? Will it still be government controlled, or will it pass into the hands of other interests and subsidies?

CAPT. IRVING L. EVANS.—The government plan, according to the best information I have, previous to our getting into this situation was to have a merchant marine, 51 per cent of which was owned by the government, the rest of it owned by the good citizens. What will be the result now, in view of the United States having such a very large merchant marine, government owned, at the expiration of the war is a problem which had not been considered, and is yet too large and yet too new for any man in the nation to decide. I think it would be unwise at this time for anybody to try to say what the policy of the government will be when that time has passed. Much will depend upon the outcome of the war, I should say. Much will depend upon the way the merchant marine is being operated at that time, the success with which it is being handled, and a thousand and one other things that might enter into the question of policy. That is certainly one which should be considered at an early date, however, as soon as the government has gotten the merchant marine in operation and things running smoothly. That is just where the board or commission to which I have referred as probably an ideal body to operate these ships could give its best services in determining during the war how that merchant marine is to be handled after the war.

K. H. OSBORN.—Has the steamboat inspection service which you mentioned authority to modify any of its requirements, or are they all the result of congressional law and beyond the control of the inspection service?

Capt. Irving L. Evans.—I would say that the steamboat inspection service is a branch of the department of commerce. Under the Secretary of Commerce there is the supervising inspector general of the steamboat inspection service. Under him come 10 supervising inspectors, the United States being divided into 10 districts. Under those supervising inspectors there is at each of the principal ports a board of local inspectors. We have the head of one of the supervising districts here at Cleveland, also a local board. Now, this supervisor's district here runs from Burlington, Vermont, to Toledo, I believe, and then the supervising inspector at Detroit has all the territory from that place to Chicago, Duluth and around the Great Lakes. There are six or eight local boards in most every supervising inspection district. Now, this supervising inspector general, with an executive committee which may be composed of the supervising inspector generals and two of the supervisors, or the board as a whole—that body may at any time modify or change these rules and regulations which specify the requirements for officers.

I wish to say that the steamboat inspection service and the department of commerce have done everything within their power to help us in the matter of supplying men for these ships. On June 13 they modified the rules and regulations to what I believe most any man who is experienced in the marine business will say is almost to the minimum. They felt that they were going as far as they should, with due regard for the safety of the property and the lives which depend upon the men who are licensed as engineers and navigating officers who handle these ships. There is a great amount of property, especially in these times, of great value placed in the hands of a few men—the chief engineer and the master; one is just as important as the other. So you can see that the requirements, especially for the higher grades, must be kept well up. The promotion from the lower grades to the higher must not be too rapid. It must give the men an opportunity to become familiar with the duties to acquire the knowledge and skill necessary to fill successfully the higher positions, in order that you people who ship your products and the people who travel as passengers may be safe, and that your lives and property will be protected. So that when these gentlemen sit there in Washington with a view to modifying these rules to let us provide men, they must at the same time consider your interests, and they do.

We have received great assistance from the inspectors, from the locals clear through, and the locals have done about all the work. The other fellows have shifted the burden upon them; but we have had excellent co-operation, and are receiving it every day. And that is one of the great satisfactions in doing this work which I am doing as a volunteer and which many others are doing as volunteers. It is the co-operation which we get from one branch of the government service or another.

I want to say that I hope I have not created the impression here that there is any friction or any misunderstanding between any of the Shipping Board interests and the Navy Department or any of its branches or auxiliaries. There is no misunderstanding whatever. There is only this effort to find a place to use these men whom they have enlisted in the naval reserves, with the expectation of using them in the so-called mosquito fleets in the coast defense, and such work, that having proved somewhat a failure, they find themselves all dressed up and nowhere to go. So now they are trying to find a place for all these fellows, including the college graduates in the merchant marine. We will welcome them in numbers, but we want a few good sailors left to

protect the lives and property.

F. H. VOSE.—The portion of the work conducted at Case School of Applied Science has been one of detailed instruction. We were asked to conduct the school during the summer months to assist in training men for engineers in the merchant marine. That work has been continued and probably will continue throughout the winter.

It has been one of the most pleasant and interesting bits of teaching that I have ever attempted to do, for several reasons. First, the men differ a little bit from the average student. They all come to the school for a definite purpose, and you do not have to exert yourself continually in order to stimulate their interest. The interest is there, and they keep one hustling all the time to supply them with information. The men all tackle the work in a fine spirit; they help one another constantly. We have had quite a number of men who have qualified and who are licensed as engineers and simply want to qualify for ocean service. These men have given us valuable assistance. They have been a fine body of men.

I want to emphasize what Captain Evans has said. I have no question but that these men, in an emergency, will respond. We have had quite a number of men from stationary practice, who have had charge of say a thousand horsepower plant, enabling them to qualify for first assistant engineer with a few months' experience.

One thing Captain Evans did not make quite clear is that before a man can enter this school his qualifications must be passed upon by the local inspector, and it is pretty largely due to Mr. Hunter's understanding of human nature that he has kept us from getting any undesirable men. All of our men come up to a really high standard.

S. H. HUNTER.—I had the very great pleasure of speaking here some three or four years ago one evening, and I did not find it a very difficult task. I have been what you might call a sailor man all my life. I started when I was 10 years old, and sailed the Great Lakes for possibly 40 years—I think it is 41 years without missing a season. I think that is enough of an introduction with regard to myself, and I offer it as an excuse for my possibly saying something which might not be just the thing, because a sailor man, as a general rule, is careless in his speech, and particularly myself when thinking about some incident that has happened to me.

It seems to me, in looking back over the 41 years, that I have had everything happen to me that could possibly happen to a sailor man and still live. I have been rolled on a barrel for half an hour. I have been ashore, the ship broken in two, the thermometer 20 below zero, five of my men killed falling in the hole, hatches gone, steam pipe and everything, and so on. But there is one point, Mr. Chairman, that I would like to make tonight. I hardly know how to bring it out. The prospect of the merchant marine to me is very encouraging. I see ahead a very beautiful picture. I wish I had the liberty or permission or authority to tell you a few of the little things which I know which cause me to feel so optimistic. We have a very generous, large-hearted, public-spirited management of our merchant marine on the Great Lakes. They are willing and anxious to cooperate in every way. All they wish is to know how; and in connection with that, this is what I wish to bring out. It is possible that you gentlemen may be able to help us. There is one man who has stopped the building of a merchant marine. He has held it back all over the world, and that man, you know his name as well as I do.

It is just possible that you gentlemen may be able to assist in killing this man, John Barleycorn. He is the man. Kill him.

The Fourth Dimension—The Engineer's Playground

By R. FLEMING*

Paper Contributed

Index No. 513.8

Is it worth while? Is the subject of the Fourth Dimension, or more correctly Four-Dimensional space, of sufficient importance to warrant attention from the engineer who has so many real things to occupy his thought? The answer is, only as a playground. He can well leave to the professional mathematician the severe mental effort necessary to be at home in the regions of hyper-space. But as a playground the Fourth Dimension offers him a field for abstract logic unsurpassed in the whole realm of thought. Nowhere else can he obtain so great an amount of conjecture from so small an amount of fact.

Professor Bryan of the Royal Society, in his article, "The Popular Fallacy of 'the' Fourth Dimension," in the *Cornhill Magazine,* sarcastically writes: "There is a certain mystical concept, described as 'the Fourth Dimension', which from time to time figures in magazines and popular journals containing articles of a semi-scientific character. This so-called Fourth Dimension appears to afford a certain fascination to some members of the professional and business classes, such as engineers, doctors, retired army officers of private means, and even millionaires who not infrequently spend their time in writing books or papers on the subject, sometimes publishing these at their own expense."

Professor Simon Newcomb, greatest of American astronomers, speaks and writes on the subject in quite a different spirit. He chose "The Philosophy of Hyperspace" as the subject of his presidential address before the American Mathematical Society. His article, "The Fairyland of Geometry," in *Harper's Monthly Magazine,* states: "We are told by philosophers that absolute certainty is unattainable in all ordinary human affairs, the only field in which it is reached being that of geometric demonstration. And yet geometry itself has its fairyland a land in which the imagination, while adhering to the forms of the strictest demonstration, roams farther than it ever did in the dreams of Grimm or Andersen."

Historical

For 2,000 years Euclid held sway in the world of geometry until about 1830 when the Russian Lobachewsky and the Hungarian Bolyai independently brought forth a self-consistent geometry, based on the assumption that through a given point more than one straight line can be drawn parallel to a given straight line. In 1854 the German Riemann originated another geometry, self-consistent throughout, based on the assumption that through a given point no straight line can be drawn parallel to a given straight line. These non-Euclidian geometries attracted but little attention until the 60's and 70's, when the foundations of geometry were studied anew by mathematicians. The properties of a hypothetical four-dimensional space then began to be developed.

Fourth Dimension enthusiasts often quote Plato and Kant. But they read into the allegory of the Greek philosopher and into the thought of the mighty thinker meanings never intended by their authors. The words *quarta dimensio*—the "fourth dimension"—were first used by Henry More, an English philosopher of the Platonist

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school. In a book dated 1671, he assigns four dimensions to spirits.

Is There a Fourth Dimension?

No, not with the meaning usually attached to the question. In our space, co-ordinates to three axes X, Y and Z, each axis at right angles to the other two, determine every point. Can there be a fourth axis, W, at right angles to each of the other three, thus creating a fourth dimension? Only as a mathematical conception can it be said that such a dimension exists. There is not the slightest evidence from the world of matter around us, the world of our experience, that space has more than three dimensions. Moreover, even if it existed a fourth dimension could not be recognized by a person knowing but three dimensions.

Attempts have been made to solve certain problems in chemistry and physics by the hypothesis of hyperspace, but full credence has not been given to the conclusions drawn. Hinton, who wrote much on four-dimensional space, believed that the phenomenon of an electric current could be explained by vibration in a fourth dimension. "A vortex with a surface as its axis affords a geometric image of a closed circuit, and there are rotations which by their polarity afford a possible definition of statical electricity." Professor Wilson of Harvard, thinks it not improbable that the time is near when physicists, in addition to mathematicians, will have to become accustomed to the use of four dimensions.

Vagaries Regarding the Fourth Dimension

Lovers of the "occult" early seized upon the idea of a fourth dimension as the road by which spirits appear to three-dimensional man in dreams, apparitions and at the invocation of mediums. Spiritualism, telepathy, theosophy, clairvoyancy, have thus been "explained" by "the fourth dimension".

It is unfortunate that the wide use of the words is largely due to modern spiritualism. The man to blame above all others is J. C. F. Zollner, professor of physical astronomy at Leipzig. During the years 1877 and 1878 the American medium, Slade, was in England and on the Continent performing his feats of slate writing, passing material bodies through each other, tying and untying knots in an endless cord, and generally mystifying the public. Zollner had more than 30 sittings with Slade and was confirmed in his belief that the world in which we live is contained in a four-dimensional space and that this higher space is the dwelling place of beings acting on the inhabitants of earth through a fourth dimension. At one of his sittings he "shook hands with a friend from the other world." Slade had been arrested and convicted in England for fraud but Zollner believed him to be condemned innocently—'a victim of his accuser's and his judge's limited knowledge." Zollner was a voluminous writer and his views were widely spread.

Time as a Fourth Dimension

In the introductory chapter of "The Time Machine", a story of unusual interest by H. G. Wells, the philosophic inventor says: "Clearly any real body must have extension in four directions. It must have length, breadth, thickness, and—duration. * * * Well, I do not mind telling you I have been at work upon the geometry of Four Dimensions for some time. Some of my results are curious: For instance, here is a portrait of a man at eight years old, another at fifteen, another at seventeen, another at twenty-three, and so on. All these are evidently sections, as it were, Three-Dimensional representations of his Four-Dimensional being, which is a fixed and unalterable thing." What the novelist uses to such advantage to adorn his tale has been considered seriously by other men. Henri Bergson, whom nowadays it is the fashion to quote, says in his "Time and Free Will": "Duration thus assumes the

illusory form of a homogenous medium, and the connecting link between these two terms, space and duration, is simultaneity, which might be defined as the intersection of time and space." (Whatever this may mean!)

If a three dimensional body were to pass through a two-dimensional region the dweller therein could be cognizant only of successive sections which would appear as planes. In the same way if a four-dimensional body were to pass through three-space the dweller therein could be cognizant only of successive sections appearing as solids. Looking along the direction of time as a fourth dimension a man would observe a new three-dimensional body each successive instant of time. The aggregate of these sections possesses the property of a four-dimensional body—the cross section is a solid or three-dimensional figure.

Lagrange long ago defined mechanics as a geometry of four dimensions, time being one of the dimensions. Four variables, x, y, z and t, are required to locate a particle in both space and time.

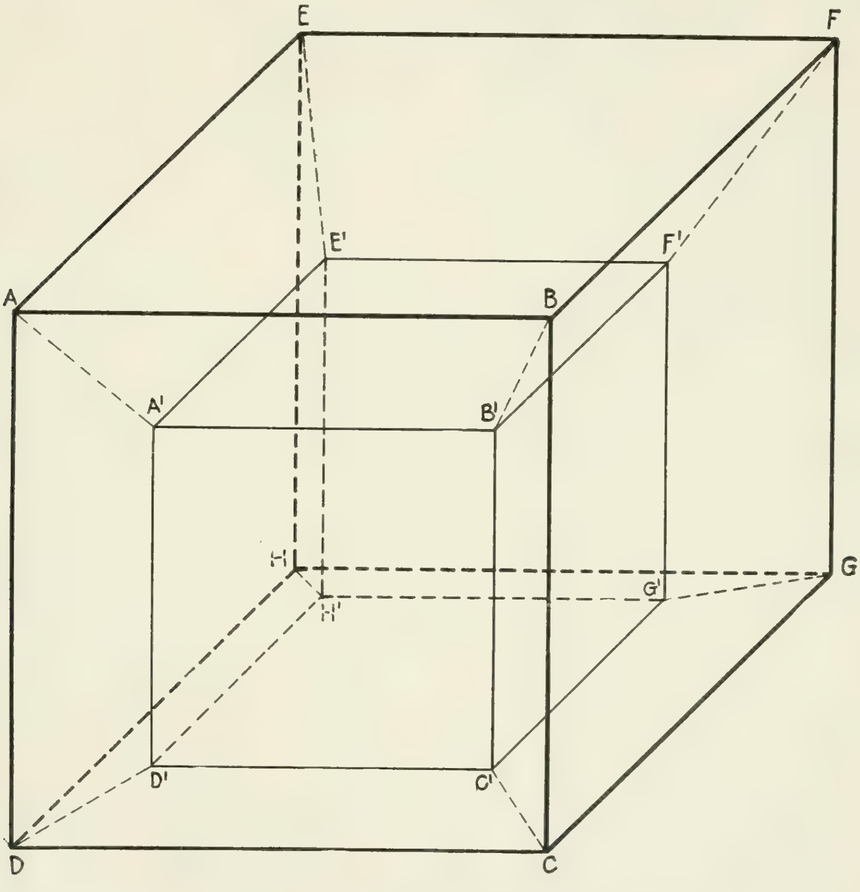

Figure 1.

The Representation of Fourfold Space

It is impossible to form a mental picture of a direction at right angles to the three we already know. We

cannot visualize a four-dimensional figure. We can, however, represent on a plane surface the boundaries of a hyper-solid. Following conventional methods, we assume a point A which, when moved in a fixed direction, generates a straight line, A B. The line A B moving at right angles to itself a distance equal to its length generates a square. The surface or square A B C D moved perpendicular to itself a distance equal to one of its edges generates a cube. It is noted that the line has one dimension; the square two dimensions at right angles to each other; the cube three, each at right angles to the other two. By analogy, if the cube is now moved in a fourth direction, at right angles to each of the other three, a distance equal to one of its edges, there is generated a tesseract, hyper-cube, cuboid, or C_8 as it is variously called. The initial cube A B C D E F G H moves along the mystical axis W a distance A B until it reaches the position A′ B′ C′ D′ E′ F′ G′ H′. It also moves in a direction perpendicular to each of its six faces forming six other bonding cubes A B C D A′ B′ C′ D′, A B F E A′ B′ F′ E′, B F G C B′ F′ G′ C′, A E H D A′ E′ H′ D′, E F G H E′ F′ G′ H′ and D H G C D′ H′ G′ C′. From the figure it is seen that the hyper-cube has 16 corners and is bounded by eight equal cubes, 24 equal planes or faces and 32 lines. Each corner is common to four edges, each edge is common to three faces and each face is common to two cubes.

As a conception of the hyper-cube, the simplest of hyper-solids, is so essential to further progress another method of presentation will be given. This is taken from *Science* (May 13, 1892). The difficulties to be overcome are considered analogous to those that an imaginary plane being, a being who has no conception of volume, would have in trying to understand a geometric solid. In his world as in ours a point moving in one direction traces a straight line and a line moving perpendicular to itself traces a square or rectangle. Beyond this he cannot proceed; for he has no knowledge of a third dimension. He can infer that a cube is generated by a square moving in a direction perpendicular to all of its sides and that each side traces a new square. He also infers that the moving square in its first and last positions forms two faces of the cube. By making a diagram (Fig. 2) he can count six faces, twelve edges and eight corners of the cube. But the corner *a* is represented as the generator of two lines *a e* which is evidently incorrect. The outer squares are therefore to be turned through 90° about their generating lines until the two lines *a e* merge into one, and the four spaces, *ee, ff, gg, hh,* disappear. He can suppose the central square to move away in the, to him, unknown direction, carrying with it the outer squares, which would then appear to sink into the center and disappear as they reached their generating lines until at last the lines *ef, fg, gh, he,* would reach the position now occupied by the sides of the square *a b c d* and become in the picture what they are really, the sides of the sixth square *e f g h*. Supposing, in the next place, that the square *a b c d* as it moves away is still visible but smaller by perspective, the plane being could draw a diagram (Fig. 3) which would represent to him the boundaries of the cube. To us it is a perspective view of the cube.

Let the three-dimension being proceed in the same way. A cube moving a distance equal to one of its edges in a direction perpendicular to all of its faces will generate the hyper-cube. Placing a cube on each face of the original cube, after the analogy of the plane being's squares, we have the six cubes shown in Fig. 4.

An eighth cube is represented by the outer faces of the six cubes. It is evident that the three lines marked *cC* are really one, the two faces *bc* are one face and so on. We may now imagine the central cube to move away

in the fourth dimension, and the others to sink inward and disappear as they reach the present boundaries of the central cube, where they turn at a right angle into the new direction. Finally all the outer faces will meet as the boundaries of the eighth cube DF. Supposing the cubes elastic, we may stretch their outer faces and diminish the inner until we obtain a perspective view of the hyper-cube similar to Fig. 1.

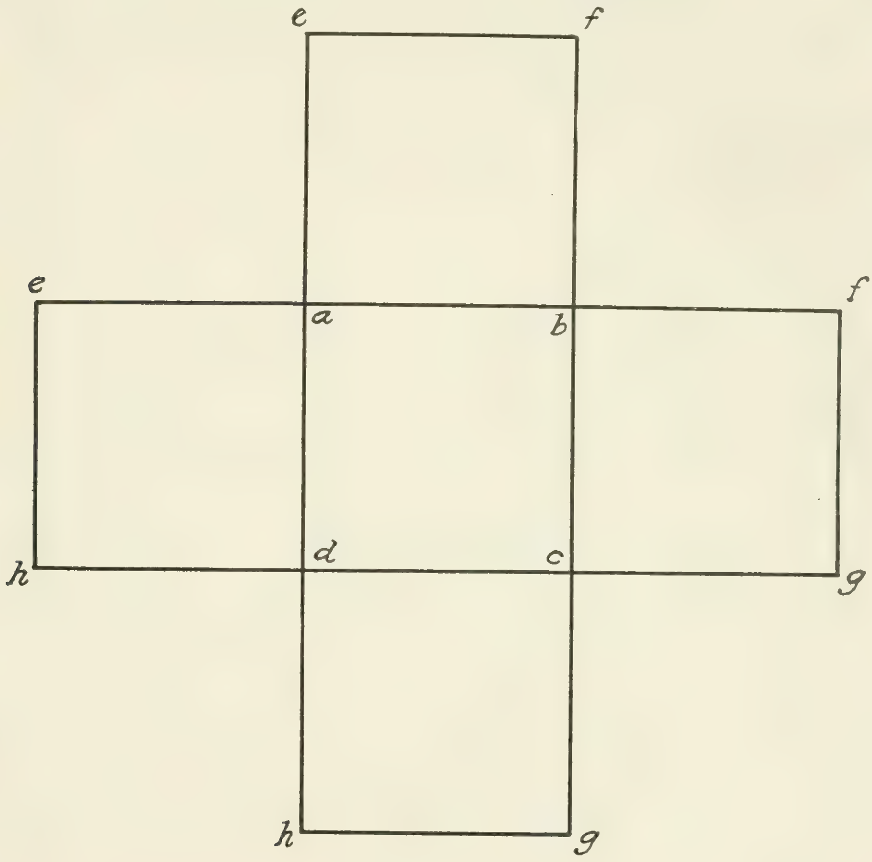

Figure 2.

The story "Flatland", by E. A. Abbott, should be read. It is supposed to be told by a dweller in two dimensions and well illustrates the limitations under which he lives. The reader's interest is sustained throughout and when the book is finished he is better able to develop relations between three-space and four-space.

Some Properties of Four-Space

The cross section of a solid or three-dimensional body is a plane, that of a four-dimensional body is a solid. In four-space, planes may be perpendicular to each other and meet only at a single point. Our knots would be only loops or coils in four-space and could be untied by carrying one loop out of our space and bringing it back in a different place. In the same way the links of a chain would fall

apart. Solids that are symmetrical in three-space about a plane could be turned around in four-space and made to coincide. The left hand becomes the right hand, the same as in a looking glass. In four-space we may have five points each equidistant from the others. In two-space rotation is about a point, in three-space about a line and in four-space about a plane.

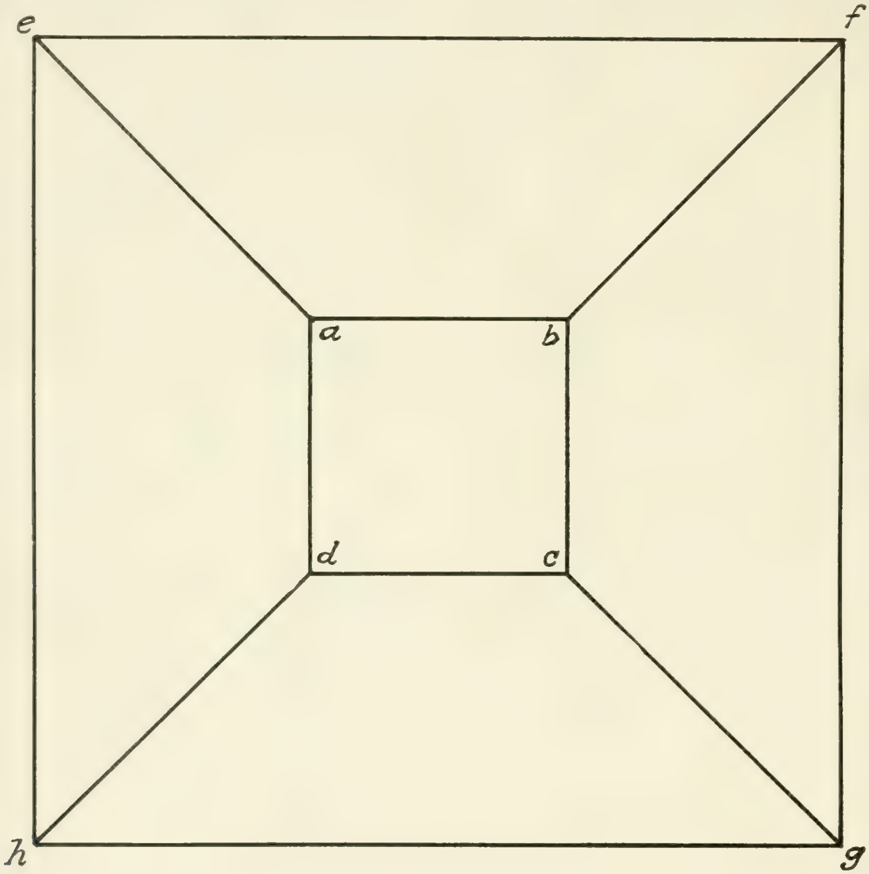

Figure 3.

The imagination can run riot with the possibilities of movement of a four-dimensional being in our space. He could leave or enter a closed room without disturbing the walls. He could extract the treasures of any safe without opening the door. The contents of a bottle could be drained without removing the cork and of an egg without breaking the shell. The fourth-dimension man could see every part of the interior of the most dense solid. The physician could see and handle the inner parts of the human body without touching the skin. Conversely, to see into a four-dimensional body an eye cannot be on the outside of the three-space man but must be in his interior. "An eye in my inside! An eye in my stomach! your lordship jests!" exclaims the inhabitant of "Flatland" to the stranger who is

endeavoring to initiate him into the mysteries of a higher space than that to which he has been accustomed.

A point starting from the center of a sphere can move by way of the fourth dimension away from the sphere without approaching the surface. There are hyper-spheres and hyper-cones and the puzzling fourth-dimensional wheel and shaft. The first number of the *American Journal of Mathematics* begins with a proof by Professor Newcomb of the proposition: "If a fourth dimension were added to space, a closed material surface (or shell) could be turned inside out by simple flexure; without either stretching or tearing." A paper in a later volume describes the six regular hyper-solids bounded by equal regular polyhedrons found in four-space. But we are off the playground. Before returning, a few theorems will be quoted from Manning's "Geometry of Four Dimensions":

"The plane of three non-collinear points of a pentahedroid, if it does not itself lie in the hyperplane of one of the cells, intersects the pentahedroid in a convex polygon."

"Two successive rotations around two different axis-planes are together equivalent to a single rotation around an axis-plane, if the two axis-planes intersect in a line."

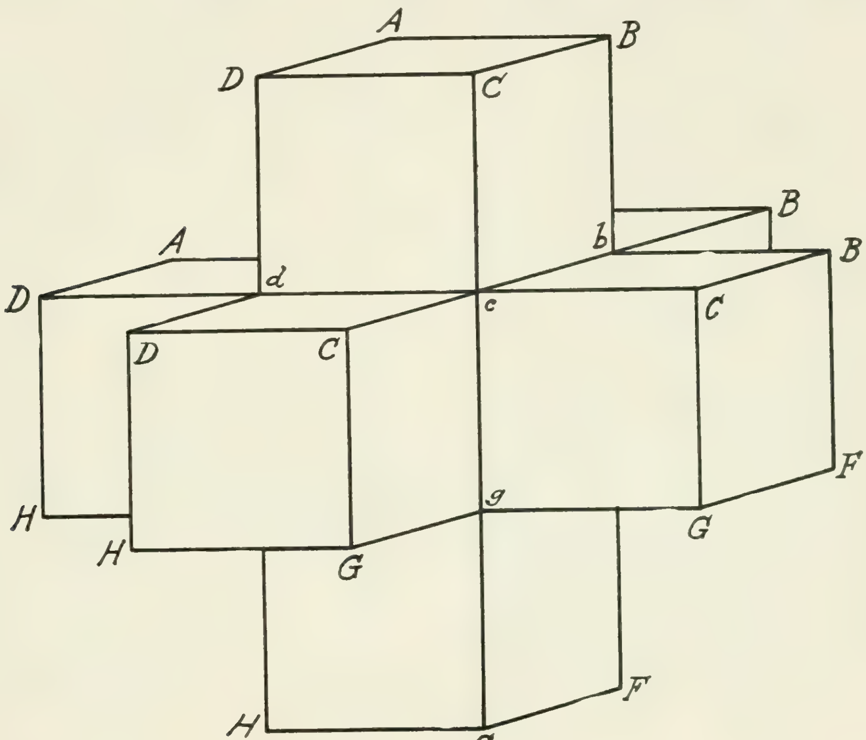

Figure 4.

"Two conjugate series of isocline planes are isocline in opposite senses."

"In a simple polyhedroid the number of cells plus the number of edges is equal to the number of faces plus the number of vertices."

"Why stop at four dimensions?" the

cynic may ask. It is not necessary. The Italian geometer Veronese has written a geometry of n dimensions. There are many other treatises, intelligible only to mathematicians, on the same subject.

The Conception of Four-Space

Hinton declares, "There is really no more difficulty in conceiving four-dimensional shapes, when we go about it in the right way, than in conceiving the idea of solid shapes, nor is there any mystery at all about it." The French mathematician Poincare writes, "Anyone who should dedicate his life to it could, perhaps, imagine the fourth dimension." The truth lies between these diverse opinions. The subejct is not an easy one. Much patience is needed. Knowledge comes gradually. Paragraphs have to be read and re-read, slowly and but few at a time.

Professor Sylvester tells in one of his mathematical papers how, as he was casting about in bed one night to discover some means of conveying an intelligent conception of his subject, there came of a sudden to his mental retina a chemico-graphical image which answered his purpose. Four-dimension solids can also be studied to excellent advantage while lying in bed. The walls of the room may be considered as trays upon which a hypercube can be built. A glimmer of light will often come "of a sudden" where all is dark.

It is well to get the viewpoint of several writers. For this purpose Manning's "The Fourth Dimension Simply Explained" is excellent. The book is a collection of 22 essays, all but one selected from 245 submitted in competition for a prize offered by the *Scientific American* for the best popular essay on the subject. The introduction and editorial notes are by Professor Manning.

Attention is also called to "The Fourth Dimension", by Hermann Schubert in his "Mathematical Essays and Recreations". Though written for "cultured people who have not had a technical mathematical training", it contains as much mathematics as the average engineer will care to read.

Of the great number of articles in periodicals, "The Fourth Dimension," by Professor Barton, in the *Popular Science Monthly,* October, 1913, may be mentioned.

The real student will find ample literature on the subject. The "Bibliography of Non-Euclidean Geometry, Including the Theory of Parallels, the Foundations of Geometry, and Space of n Dimensions," by Professor Sommerville, of St. Andrews, Scotland, is a book of 400 pages. About 1,800 of the references are made to books and articles, largely in languages other than English, on geometry of n dimensions.

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Cleveland's Sewerage System

By Robert Hoffmann*

Paper Presented October 30, 1917.

Index No. 628.2

The first sewers built in Cleveland under city direction were probably constructed some fifty or sixty years ago. A few of the early sewers are still in use. As the city increased in size the importance of sewerage became more manifest and many sewers were built. This increase in the mileage of sewers never apparently kept pace with the demand nor the increase in street mileage, due largely no doubt to the rapid growth of the city and financial complications.

One of the early studies of the sewerage situation resulted in placing in many of the streets, now forming the business center of the city, small pipe sewers, patterned after European practice of that day. All of these sewers have been replaced by larger and deeper ones, as the old ones proved inadequate through changing conditions.

The art of building sewers as now constructed has been of comparatively short existence, and has developed largely along with the growth of modern cities during the past forty or fifty years. Of necessity the early sewers were designed largely on assumptions, without proper basis, or so as to fit the then existing conditions only without due regard to future growth.

The engineer of today is in much better position to intelligently design sewerage systems than was his predecessor, as he has at his command a large amount of data bearing on the subject, which the early engineer was denied. Studies and observations relating to frequency and intensity of rain storms extended over a period of some fifteen or twenty years and furnished the first reliable data required in designing storm sewers. Similarly studies were made to determine the proportion of the rainfall which reached and was carried off by the sewers, and the rate in which this took place.

Observations were further made to determine the rate and fluctuation in the flow of sanitary sewage. Tests were made to fix the capacity of conduits of various sizes and of different material, so that the size of sewer would have a proper relation to the work it was supposed to perform. These studies and observations required many years and incidentally exposed many improper designs, largely the result of inadequate information. Though observation of conditions having a bearing on sewer design are still desirable, the engineer of today is in possession of so much data relating to sewer design that his work should be much more efficient and lasting than that undertaken thirty or forty years ago when much of the required information was lacking.

It can therefore be seen, that the sewer experience of a modern city has been largely the history of the art of sewer building, in which each engineer did his part in accepting and attempting to improve upon the experience and work of his predecessor. None should be blamed just because his work in light of present-day con-

*Commissioner of Engineering, Cleveland, O.

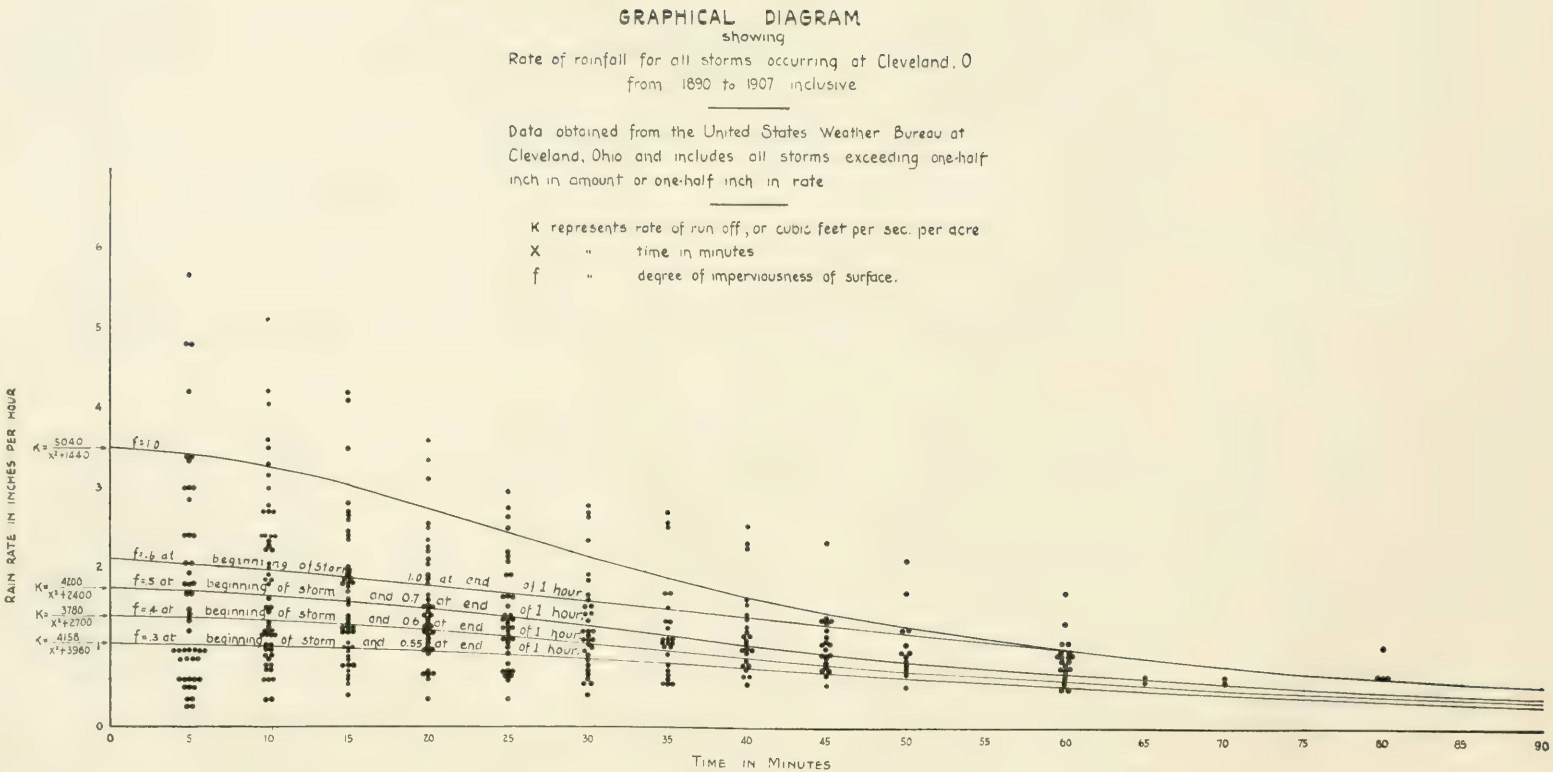

Plate No. 1

Rainfall curve. Time factor must be estimated for each drainage area, and factor of imperviousness assumed. Second line from top commonly used.

ditions, seems inadequate, for he may have shown the best of judgment and ability at the time of its construction.

For the most part the sewers of Cleveland are of what is known as the "combined system", that is, both the sanitary sewage from the plumbing appliances of the buildings, and the storm water at times of rain, find their way into and are conducted away through the same channel. In a few suburban sections separate sewers have been provided for the sanitary sewage and the storm water, thus constituting for such sections what is known as the "separate system".

Lake Erie is the ultimate outlet of all the sewage, whatever its nature, that flows through the Cleveland sewerage system. To avoid building large expensive sewers all the way to the lake shore, use has been made of the various creeks and rivers that flow into the lake for sewer outlet purposes. In order not to unduly contaminate such streams with sewage pollution, the plan is to empty into such streams only the flow from sewers after being diluted by the storm water. The ordinary daily flow is conducted past such storm-water outlets along a system of sewers which ultimately carries it to a point of final disposition, where it may be properly cared for. This introduces into the sewer system a number of so-called storm overflows in which the amount of flow which is to continue in the sewer, and also the amount which is to discharge into the stream is regulated.

The sewer system of the city may be described as a series of main sewers having outlets for excess storm water, either directly into the lake or into streams connecting therewith, and from which systems the daily sanitary sewage, together with a certain amount of stormwater as a flush is intercepted by means of a system of intercepting sewers in which the sewage is carried to certain points of disposition, where it may be adequately treated before being discharged in the lake or river.

Probably all materials used in sewer construction have been used to some extent in the Cleveland systems. Principally, however, brick masonry and vitrified earthenware pipe have been employed. Concrete has been largely used for foundations, and to some extent in reinforced monolithic construction for the arch of the sewer. A few sections of sewer have been built of concrete block, and a few sewers have been built of the segmental block type made of vitrified shale.

As stated before the rate of rainfall is a controlling element in the design of a sewer. Well-known formulas have been devised and used for the purpose of fixing the size of a sewer in proper relation to area of the drainage district in a manner similar to that adopted in most cities. Locally rainfall observations made over a long series of years were noted and platted and a rainfall curve fixed, which is now generally used in fixing the design of our sewers. This curve makes due allowance for the varying intensities of rainfall as a factor of the time element, and also takes into account the probable proportion of such rainfall which may reach the sewers as affected by the imperviousness of the soil. All such formulas and curves must be used with a considerable degree of judgment, based on knowledge of special conditions affecting the special problem being considered. This phase of sewer design is a complicated problem in itself upon which many papers have been written, and will not be discussed here. Our experience seems to show that few sewerage systems capable of discharging a cubic foot of flow per second per acre of drainage area causes much trouble by reason of sewers being overtaxed and a consequent flooding of basements along their routes. This would not be a safe basis to assume in territories all paved and built up so that a large portion of the same are under roof, as a more

liberal assumption must be made in such cases, but it does answer fairly well in residence districts, or where existing systems are being studied with the idea in view of rebuilding if found of insufficient capacity..

The basis assumed for the dry or sanitary flow has been an average flow of 100 gallons per day per capita is diluted with from three to five parts of storm water, so that no nuisance or dangerous sewage contamination may occur at the points of overflow.

The design of sewers being based on drainage area and population, it requires considerable study to establish intelligently the maximum area of such drainage district and its ulti-

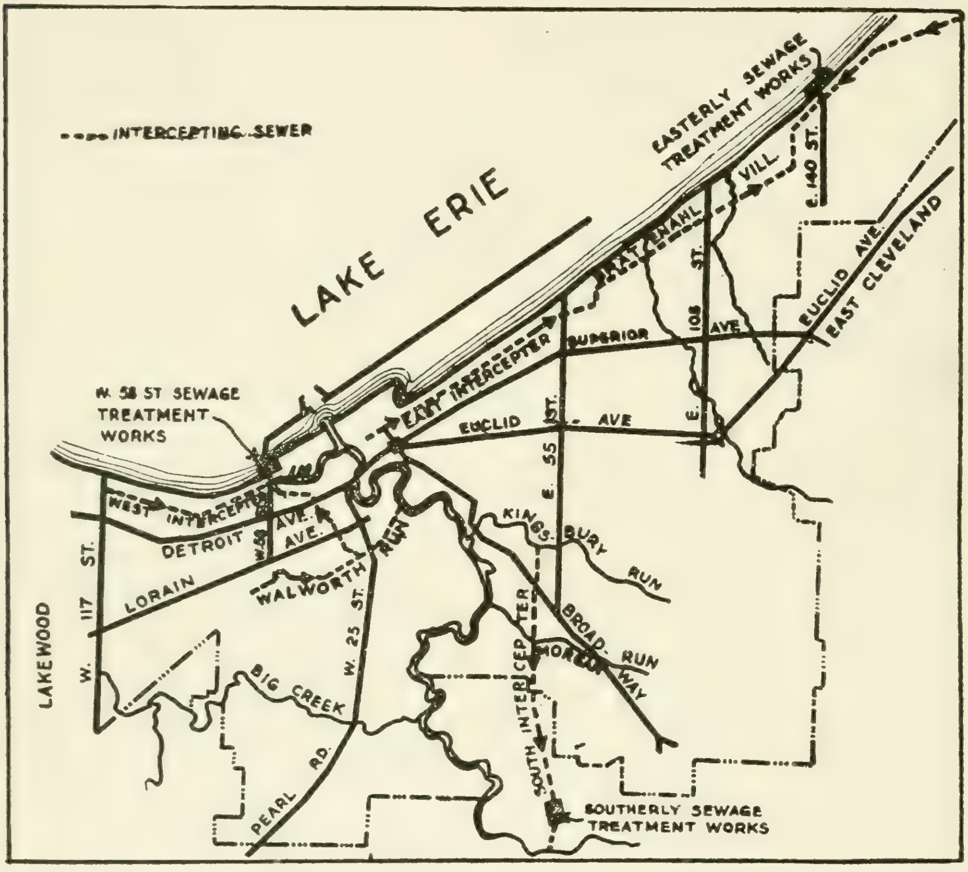

PLATE NO. 2

City map showing sewage disposal plants.

with a provision of 400 gallons to provide for maximum rate of flow for a short duration of time, and in order to make allowances for some infiltration of ground water as well as a certain flush of rain water. Where overflows are used they are so designed that no sewage shall overflow into the storm outlets until the sewage mate population as well. This, it can be readily appreciated, demands the exercise of good judgment in attempting to forecast trend of business development, growth of population, and possible plans of future sewer construction. Plans for further sewer construction are peculiarly important as in many cases natural drainage

areas may extend far beyond the limits of a city, and to assume the entire district as urban territory might so increase the size of a sewer as to render it financially impossible of construction. In such cases one may be warranted in reducing the size to fit existing conditions, partly urban and partly suburban in character, if a suitable method of relief may be seen through the construction of other sewers in the future when conditions make the same necessary.

The elements of sewer design make a most interesting study, furnishing as they do a combination of assumptions and realities, offering great opportunity for the exercise of good sound judgment.

Up to the present, as before indicated, the sewage of Cleveland has been finding its way untreated to Lake Erie. The increasing quantity of sewage, directly dependent on the increase in the city's population, is establishing something of a menace to water supply, and also a source of nuisance and danger to the occupancy of the lands along the lake front of the city and adjacent communities. This condition having been recognized some years ago, studies were made with the object of determining the quality of the sewage and the proper method of treating it so that the effluent which would finally be permitted to discharge into the waters of Lake Erie would be free from nuisance or harmful effects, either to the citizens of Cleveland or those of neighboring communities.

These studies have been practically completed and tentative plans made for sewage disposal, so that now the department having this work in its charge is ready to proceed with the construction work. In fact, considerable progress has been made. The general plans contemplated three sewage disposal plants. One known as the easterly plant will be located on the shore of the lake at East 140th street, and will treat sewage coming from the territory east of Cuyahoga River and north of Woodland avenue. The southerly plant located adjacent to Cuyahoga River, near East 71st street, and the garbage disposal plant will treat the sewage coming from the portion of the city east of Cuyahoga River and south of Woodland avenue. The third plant will be at the westerly end of West 58th street at the lake shore and is to treat the sewage from the westerly part of the city. These treatment districts are only approximately described herein for the purpose of general location. The land required has in each case been secured and a part of the work of construction completed. As the exact method of treatment has not been fully approved, only such portion of the work was placed under contract as could be used to advantage in whatever method of final treatment might be adopted, and consisted principally of preparation of site, excavation work and outlet conduits.

Not all of the preparatory work to sewer construction is confined to the making of plans and letting of contracts. The preparation of legislation so that the work may be authorized and financed is one of the necessary preliminary duties demanding careful attention and a thorough understanding of the law governing the same. The cost of sewers is partly paid by owners of property abutting upon the street in which the sewer is to be constructed and partly by the city at large. Under existing laws the city as a whole must pay the cost of the portion of any sewers located within street intersections and at least two per cent of the remaining cost in addition. Abutting property cannot be made to pay more for any sewer than would be required to pay the cost of a local sewer, so that the excess cost of any branch or main sewer over and above what a local one would cost, must also be borne by the city as a whole.

The abutting property owners' portion of the sewer cost is obtained by taxing such property either by

the foot front or by the benefits accruing to the land by reason of the sewer construction. The benefit method is followed in the city of Cleveland, but usually such benefits are taken to be proportional to foot frontage of most lots. It can be readily appreciated that in order to properly tax the abutting property so as to secure the landowner's portion of the sewer cost, careful preparation of the legislation is most important. The sequence of steps taken locally in this connection is as follows: The member of council signs a request that legislation be carried on in his name for the purpose of building a sewer in a certain street. The preparation of the legislation is then carried on as a routine matter by engineering and finance departments and submitted to the council for action as needed. There is prepared a plan showing size of sewer, rate of grade, depth below surface, material to be used in consruction, and the land which is to be taxed for the improvement.

From this plan the estimated cost of the work is made, which together with a resolution declaring the intention to construct the sewer and to tax the cost thereof upon the benefited property is sent to the council for approval and adoption. A copy of such resolution is served upon every property owner subject to a local tax for the improvement, in which copy he is advised of the time and place of public hearing, where complaints, criticisms, protests or favorable comments may be made. Such hearing is before the Board of Revision of Assessments. Prior to such meeting the Commissioner of Licenses and Assessments has prepared the estimated assessment which it is proposed to charge against each property ownership. If the improvement is to proceed the Board approves the assessment and the council is duly advised of such action.

Next an ordinance is passed by the council providing for the levying of the tax and ordering the construction of the sewer to proceed. The tax to be levied against the abutting property is then certified to the County Treasurer for collection, by whom the proceeds from such collection, less the legal collection fee is turned over to the city to be used in paying for the sewer construction. The payment of the sewer tax is usually spread over a term of five years each annual tax being payable in two installments.

It is not required, however, that the building of the sewer shall wait until all of the payments have been made, but the city usually borrows nine-tenths of the total tax in anticipation of the collection after the first installment of one-tenth has been paid. The borrowing of the property-owners' part of the cost is done through the issuance of bonds or notes which are paid off as the tax is collected.

The city's portion is usually secured through the sale of bonds issued for such purpose. These bonds according to present practice are paid off serially and all mature well within the estimated life of the improvement.

It may be readily appreciated that this rather complicated method of legislation consumes considerable time. Unless sewer legislation be begun before June 1st it is hardly possible to arrange for the sewer construction as early as the following year. Therefore, any construction which it is proposed to undertake during the year 1918, for instance, and in connection with which a tax is to be levied, must have had its legislation, as herein described, started before June 1st, 1917.

This fact alone shows how necessary it is to prosecute sewer construction in accordance with some well-defined program, in which the financial obligations of both the abutting property owner and of the city as a whole, may be anticipated.

The bonds issued to pay for the city's part of the cost of sewer construction are subject to the statutory limitations, and therefore the city council can under existing conditions

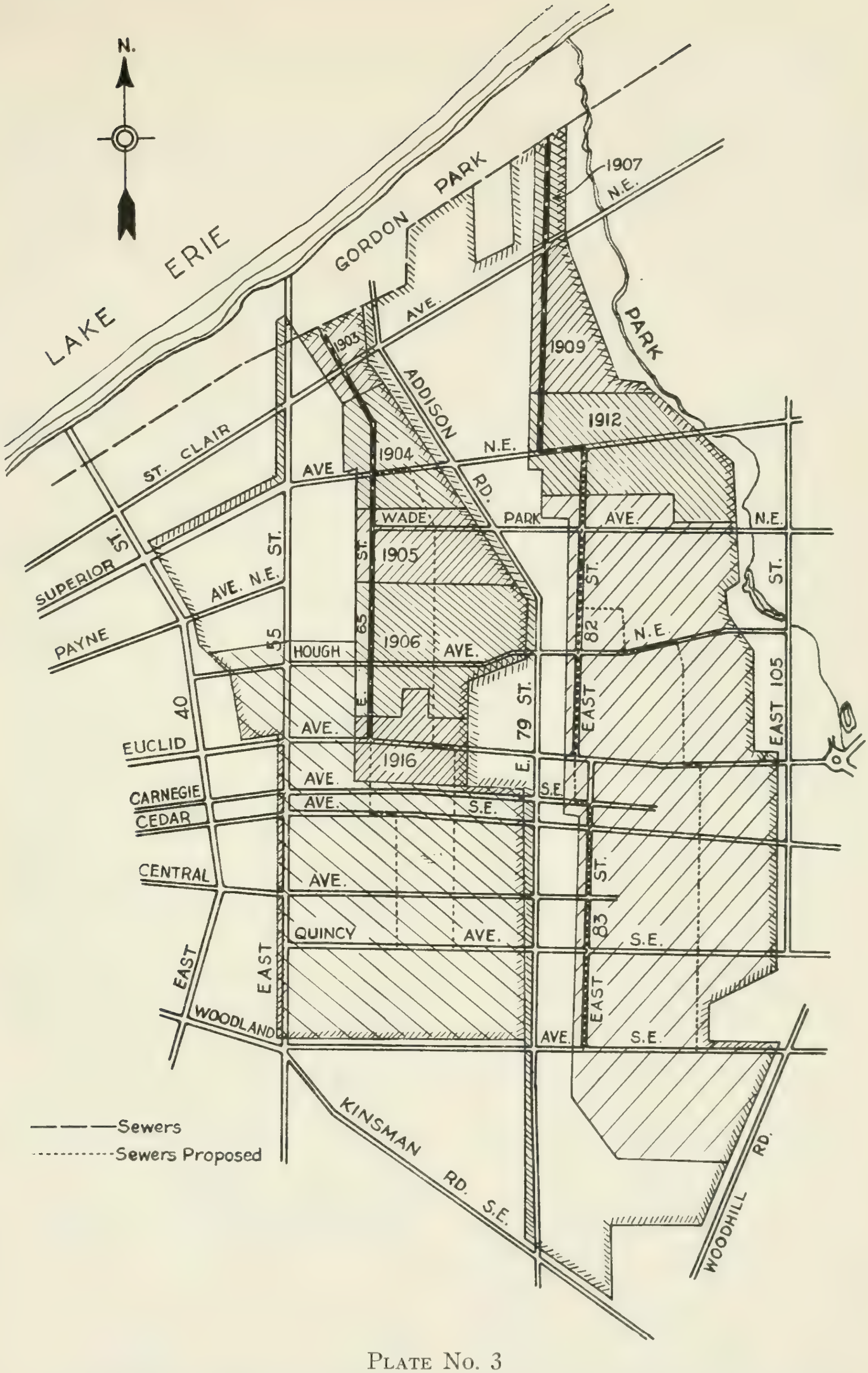

PLATE No. 3

Map showing slow progress in construction of the E. 65th street and E. 82nd street relief sewers. The intermittent progress of sewer construction is shown in this plate. The shaded areas indicate the territory which the relief sewers in E. 65th street and E. 82nd street are supposed to ultimately drain and thereby relieve sewers in E. 55th street and E. 79th street now severely overtaxed at times of rain storms. The E. 65th street sewer as shown on the map was begun in 1903. Further work was done in 1904, 1905, 1906 and 1916, but sewer and proposed branch connections are still less than one-half complete. The E. 82nd street main sewer was begun in 1907. Further work was undertaken in 1909 and 1912. Relief system is less than one-third complete.

provide only for relatively small issues without the vote of the people. The total issue of bonds of Ohio municipalities authorized by city councils alone is limited to 2½ per cent of the city's tax value. As the amount of outstanding bonds is nearly up to such limit, council can only issue annually a limited amount of bonds made possible through the growth of the tax duplicate or by paying off some outstanding bonds.

The modern city has many demands for funds, for other than operating purposes, and for which it is customary to provide by the issuance of bonds. There may be mentioned pavements, sewers, bridges, grade crossings, parkways, street extensions, public halls, fire and police stations, playgrounds and harbor improvements.

It can readily be seen what happens when the annual demand is made by the various departments having these important matters in charge, for funds required to keep pace with a growing city's needs. If any of the available bonding power is used to raise the funds required, it is usually only a small part of the amount requested, or if any particular field is fully provided for the others may be obliged to go with no such provision whatever.

Though in Cleveland the sewer department has always been considerately dealt with in this regard it has seldom been possible for the council to provide funds, through issuance of bonds, in an amount sufficiently large to adequately provide for projected work. As this condition has been repeating itself from year to year the projects unprovided for have accumulated until they have piled up to a considerable value.

Legislation for sewers has continued, and thereby has imposed upon the property owner a tax which he must pay. At the time of levying this tax, however, there was no way of telling definitely whether the city's portion of the cost of the work would be forthcoming when required. The existing arrangement is therefore that the property owner must pay in his share of the cost of the improvement and the city pays its part perhaps and when it has funds to do so.

There has been no proper control of sewer legislation enforced. Obviously it is undesirable to tax property for an improvement earlier than necessary, and for that reason then there should be some check on legislation so the proceedings could be stopped until it became certain that the city was in position to finance its portion of the cost.

There is very little difficulty in financing the property owners' share of the cost of sewer work, as the tax which is levied is sure to provide funds for the payment of the loan, thereby making such loan easy to secure, and as loans of this kind do not count against the city debt limit, the complications arising in providing for the sale of city bonds do not take place.

As a result of this method of carrying on legislation there are now about 100 sewer projects started upon which property owners are either paying tax or will be in January, 1918. The city's contribution which will be required to construct these 100 projects will amount to over three-quarters of a million dollars. There are in addition some twenty projects for main sewers, some partially completed, for which the city must pay the entire cost, as they will be built in locations where the existing sewers are adequate for local needs or else in places where local sewers are not required. It is estimated that these projects will cost nearly a million dollars.

In addition to these two groups of sewer projects, one must also provide for sewering recently annexed portions and for completing the sewer systems in other partially undeveloped lands within the city. It is interesting to note that at present the city has about seventeen miles of streets to the square mile of area. It has less than fifteen miles of sewers to

the square mile. To bring the sewer mileage to the street mileage means adding about 106 miles to the sewer length. In the portions of the city fully allotted there are about 25 miles of streets per square mile. It seems reasonable to predict, therefore, that before many years there will be an average of at least twenty miles of streets per square mile. This would mean an additional amount of 265 miles added to the sewer system even if the area of the city, now about 53 square miles, does not increase. This makes a net additional sewer length of 371 miles which may require construction in the not distant future.

It has been estimated that the city's portion of the cost of sewer construction may be averaged at $10,000 per mile, which would yield a prospective expenditure of over three and one-half million. The electors of the city are to vote at this coming election upon a project to authorize the issuance of $3,000,000 worth of bonds for sewer purposes.* It seems quite evident from the foregoing that there is ample opportunity to expend such an amount. Let us look further into the desirability of sewer construction.

It must occur to us at once that in a modern city property without sewer facilities is undesirable and not in demand and therefore has less value than land located where sewerage is possible. This means that in the first place the land cannot be used to its best advantage, and next that the city does not get the benefit of tax upon the increased value which the sewer would give. Not only does the land increase in value, but sewering makes it possible to improve the land with buildings which again increases the tax duplicate and yields the city revenue. In this connection it would seem that a sewer is a distinct asset, adding value and increasing income, and should therefore not be considered as causing an indebtedness.

In the built-up section of the city where sewers of inadequate depth or size may exist, the replacement of such sewers by properly designed

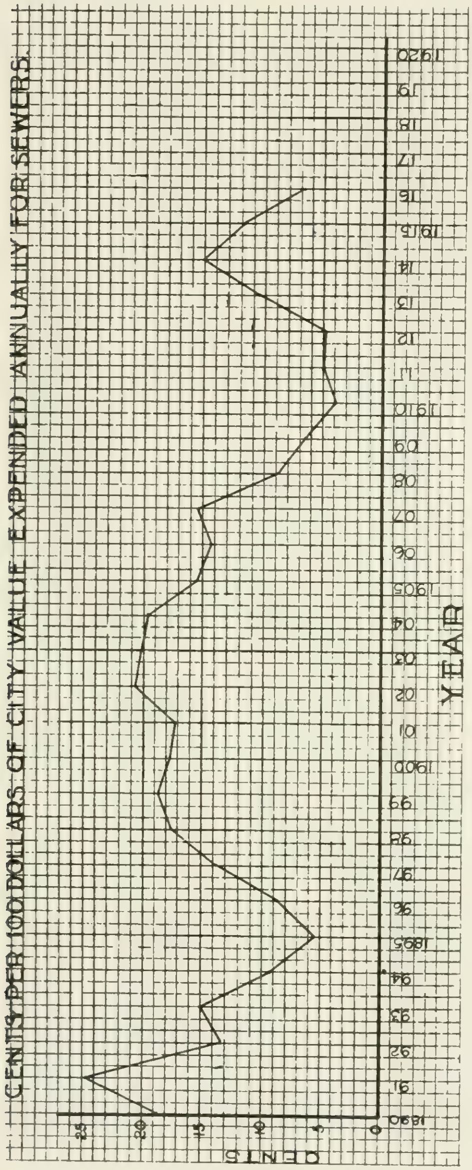

PLATE NO. 4

Showing relation between city tax duplicate and expenditure for sewers. Until so necessary a thing as the sewer system is quite complete, it would seem justifiable that the annual expenditures for sewers should bear some consistent relation to the tax value of the city. That there is no such relation, and that the expenditure seems spasmodic is shown by the diagram in Plate No. 4.

*Approved by the election Nov. 6, 1917.

ones may again give much added value to the property by reason of its permitting deep basements and the free use of same without fear of sewage backing up into such basements at times of storms and destroying whatever may be stored therein. The alleviating of conditions such as this seems peculiarly an obligation upon the part of the city. In the newer sections, where adequate sewer provisions have been made, such trouble

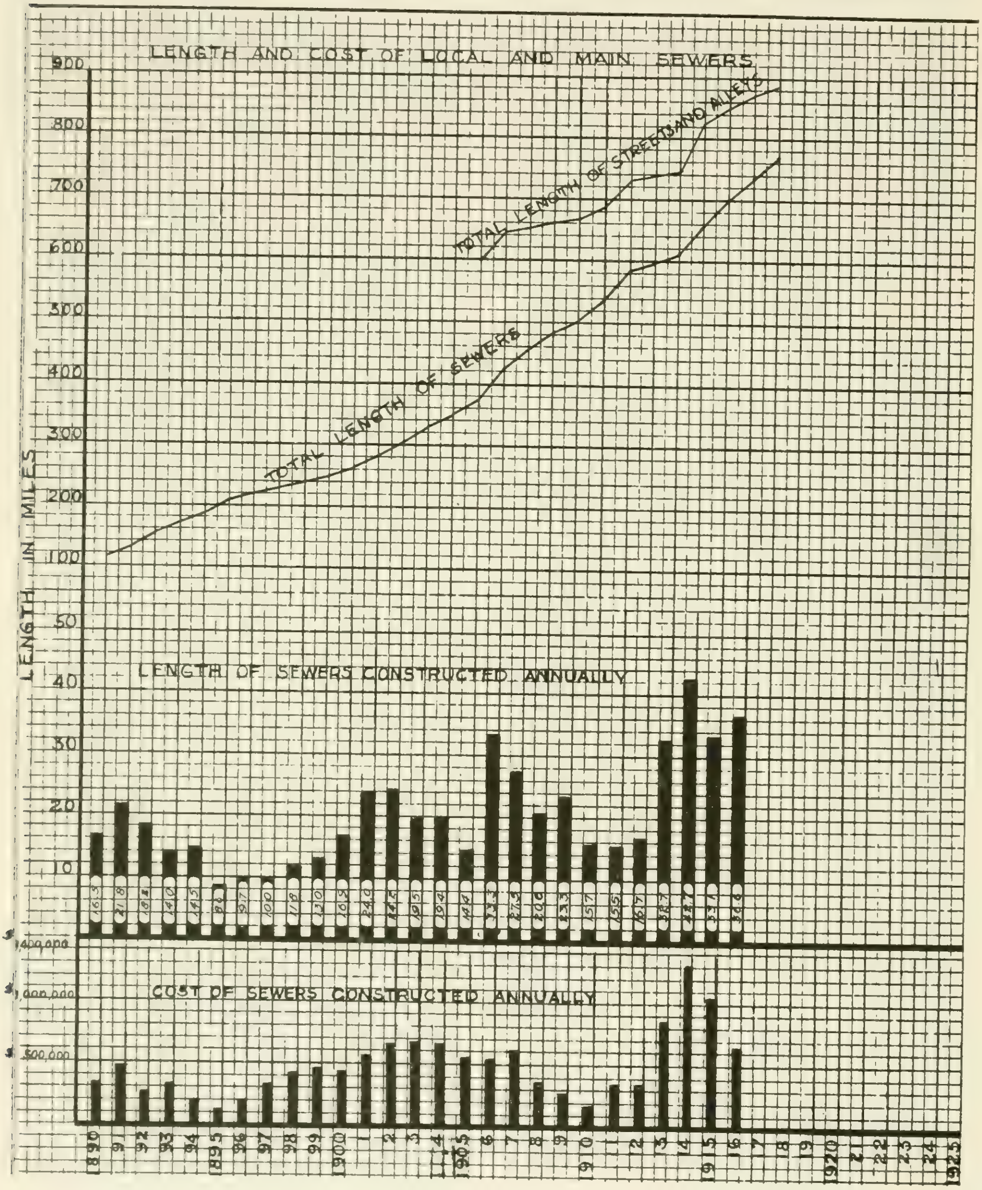

PLATE NO. 5

Diagrams showing progress in sewer construction and relation between street mileage and sewer mileage.

does not exist. The older parts of the city, however, were all taxed upon a relatively high valuation to pay their share of the city's part of the cost of the sewers built in the newer sections. It is therefore only just that the newer sections should reciprocate and pay their share as may be required in remedying sewer conditions in the older sections of the city, where trouble may be experienced.

An extensive program to repave streets has been inaugurated. The modern pavement is an expensive affair and surely should not be laid in a street where there is a sewer liable to require a repair at most any time, or where it is known that the sewer was either too small or so shallow as to make rebuilding desirable within a few years. We should be in a position to provide for such a contingency by rebuilding the sewer. There are now several miles of streets where sewers should be rebuilt, so that the type of pavement required by modern traffic can be laid.

It is not to be assumed that all this work must be undertaken at once. In fact that would be impossible. The bonds if authorized should be sold only in such amounts as may be required from time to time in laying out a season's work. It may even be that our conditions may make desirable that but little work be contracted for immediately. Knowing, however, that the work is justified in the minds of the people and that its financing is assured, makes it possible to approach the problem in a scientific manner.

One of the first things necessary is to provide an adequate engineering force so that a plan of procedure may be intelligently adopted to extend over a period of four or five years at least. This means a thorough examination of existing drainage systems so that all inadequate provisions as to physical conditions, size and depth may be established. After all necessary data in this connection are obtained the new sewers which are to replace or relieve the old ones should be designed, and the most necessary ones placed under contract for construction. Much of these data are now at hand and many of the weak spots known, but the department has not been equipped in recent years with the necessary engineering force to properly undertake this work.

Considerable field work is also required in the sections not yet provided with sewers and where extensive topographical surveys should be made. Good thoughtful design of sewers may save thousands of dollars over sewers hurriedly made based upon inadequate information. Undoubtedly an entire year could be given up to this work. All work of construction would not necessarily be delayed until this preliminary work is completed as many of the sewers now ready for contract have received sufficient study to warrant their construction, as the plans have been worked out by existing engineering forces.

Unfortunately the personnel of the Sewer Department has changed frequently from one cause or another so that but few men have had an opportunity to become thoroughly acquainted with local conditions or well versed in the science of sewer design. Salaries should be adjusted from time to time so as to make an inducement for competent engineers to remain in the employ of the city as well as to make the securing of their services possible. Engineers as a class should be interested in this phase of the problem, as it means proper recognition of the profession and adequate reward for most useful service.

It may be of interest to name a few of the projects which require attention. Among the main sewers needed to relieve territory subject to flooded conditions may be cited part of East 105th street, East 82nd street and East 65th street, which will relieve the sewers in Superior avenue, Wade Park avenue, Hough avenue, Euclid avenue, Carnegie avenue, Cedar avenue, Central avenue and Quin-

cy avenue, East 30th street, south of Chester avenue to Cedar avenue, parts of Scovill avenue, Central avenue and Woodland avenue. Further extension of the West 45th street main now constructed as far south as Franklin avenue. Relief sewers in the vicinity of Pearl road and Broadview road.

Sewers needing rebuilding in advance of paving are located in Carnegie avenue, East 22nd street to East 55th street; on parts of Superior avenue, on East 140th street, north of the New York Central R. R., parts of St. Clair avenue, Kinsman road, Woodland avenue, Clinton avenue and Franklin avenue.

Sections without any adequate sewers and where the want of them is seemingly holding back development, are located in parts of Collinwood, Nottingham, Euclid, Newburgh, Corlett and South Brooklyn, all being sections annexed to the city in recent years.

There are also a number of streams such as Burke rook, Morgan Run and Nine Mile Creek which must be maintained as storm water outlet channels which should be converted into sewers so that the gulleys in which they are located could be filled and converted into useful territory.

These are but a few of the proposed projects taken at random, and are illustrative of the kind of work required. No one who investigates the proposition can be otherwise than convinced that the opportunity and necessity for an extensive program of sewer construction exists.

That additional bond issues under existing financial conditions are undesirable cannot well be disputed. The interest and sinking fund charges must reduce the amount anually available for operation expenses unless the growth of the tax duplicate is sufficient to counteract such effect, but unfortunately at this time no other method of financing seems possible than by bond issue.

There are some projects that must continue with the growth of the city. To retrench on sewer construction will probably mean great loss and expense by reason of the absence of sewers. Both as a sanitary measure and as a business proposition a reasonable amount of sewer construction seems necessary even in the critical war time conditions of the present. Under the circumstances the pending bond issue of $3,000,000 seems a sane, desirable and necessary project.

DISCUSSION

H. W. S. WOOD.—I think Mr. Hoffmann has gone over the sewer situation so that we can understand it.

If I should go back and call to memory the first sewer, I would have to think of my father and W. P. Southworth, founder of the store over here on Ontario street. It was in a street called Spring street, which is now, I think, partially vacated. An open public sewer ran along Spring street to the lake under the old depot, the depot being built on piles driven adjacent to the lake. I think that was the first sewer. That was 66 years ago. Mr. Southworth built a small stone and brick sewer under the depot at Spring street, and then connected the open Spring street sewer into it.

Now, there are a few little incidents I would like to call to mind to show you the necessity of sewers. It was impossible to build a large city such as we have here today without the constant improvement of the sewers.

Mr. Hoffmann spoke of the Walworth sewer. I remember perfectly well a sewer on Pearl street, now West 25th street, that ran into Walworth Run. The sewer was put down fifteen or eighteen feet. Time passed on, and they connected other sewers to it, among which were sewers in Lorain street and Race street. Later West 25th street was filled up to the level of the present bridge, which left the sewer down about forty or fifty feet. One evening James Curtiss,

who was then a member of the city council, was driving home from council meeting in a carriage. There had been a heavy rain storm and the sewer had broken in under the street, and down went Mr. Curtiss, the carriage, driver and everything, into the hole some thirty or forty feet deep. Mr. Curtiss forced the door open, reached up and grabbed the overhanging street car track and saved his life.

When the Root-McBride block was completed they had a basement full of drygoods in the wholesale line. The sewer was connected to the Bank street sewer. A storm came up and filled the cellar, and the drygoods were all under water. That brought on the enlarging of the sewer system down there.

I might also mention Euclid avenue. I think it was in the E. M. Coe piano store on Euclid avenue, I saw some forty pianos floating around in the basement. The sewer had backed up. There are other parts of the city which I might mention, such as Woodland avenue, at Dorn's shoe store, where I have seen boots and shoes floating around in the basement. In some of those cases the city was sued for damages, but I never knew anyone to get a cent. When they built the sewers they passed an ordinance as they do now, and the court ruled that an owner of property on the street was a party to the making of the plan of the sewer, and he could not sue himself.

Now, let me tell another little incident. It is old, so it will not do any harm. There was a house down on Center street, a three-story brick building, connected to the sewer in the street. The sewer backed up, and the force of the water coming back undermined the walls and the building fell down. They went into court. Judge Foran, I believe, was the attorney in that case. They tried the case for a week, and of course they got nothing. Now, I am not supposed to know anything about it as a contractor in doing work for the city, but in that particular case—of course the engineering men knew nothing about it—the Gas Company had run their gas pipe right through the center of the sewer. Of course that stopped up the sewer and the water naturally would go back.

Those are a few little incidents that we had to put up with. Of course, Mr. Hoffmann now, with his 16-foot sewer, is not troubled that way.

The building of a city, gentlemen, is a great problem. I have been connected more or less with public improvements for some thirty or forty years, and I see the difficulties which confront the engineer. He has not only to contend with the engineering difficulties, but the general conditions leading up to making that plan.

I might call to mind Walworth Run. There was a condition where all the sewers in that section of the city were drained into Walworth Run. They then established the stock yards at the west end of the run two miles from the river, where they ran all the refuse as well as the sewage from the main sewers from a territory two miles square, into Walworth Run. They wanted a sewer to serve Walworth Run, to get rid of that refuse. The resolution which was first introduced into the city council to build Walworth Run sewer was passed just thirty years before they commenced building the sewer. It was something I happened to be interested in, and we waited thirty years. What was the result? Factories that wanted to do business along the railway paralleling Walworth run would not establish their business there. They established a few oil refineries there in the 60's. They were there for a short time, until the Standard Oil bought them out. Not having that run improved drove business away. There was an instance where the delay in improvements set the value of the property back and kept it back until such time as the city finally came to its senses and built that sewer. That is one of the little inci-

dents in building a city which we are up against.

I want to say here that I do not believe there is a public improvement, such as sewering, water, or paving, that should be stopped for one minute when it is necessary to go on and develop this city. I have that feeling from going away back when I had to pull myself across the Cuyahoga River on a flat boat at Center street. There was a bridge across at Columbus street, but we drew ourselves across on a flat boat by means of an endless chain at Center street. From the time the first viaduct was built to the present time you have not made an improvement in this city but what has benefited the city and increased its value and brought population and business here. I can remember distinctly sixty-five years back, and from that time to this in Cleveland, every improvement that has gone on has developed another improvement. The result is that you have got what you have today. You are here today receiving the benefits of what we old fellows laid the foundation for, and I as a citizen now wish to congratulate you that you have these advantages.

J. A. PHELPS.—I would like to ask something about the condition of the sewer outlet at White City. Does the sewer outlet there contaminate the lake, and is there any plan being made to overcome that contamination, if there is any?

ROBERT HOFFMANN.—White City is the location of one of the proposed sewage disposal plants, of which general plans have been made. At present, sewage in an untreated condition goes into the lake. There is a submerged outlet there extending about half a mile from the shore laid along the bottom of the lake to where the sewage is discharged. At times of storm more water collected, more sewage, than the submerged pipe can take, and part is spilled directly into the lake. Of course, there is a certain amount of contamination which must take place under those conditions. There is a plan to place a proper treating station at that place. We have now under contract the laying of an additional submerged pipe, which will take care of the amount of sewage coming to that point for some time to come. In connection there will also be built a disinfection plant, so that the sewage may be disinfected, especially during the summer time. But it is intended at such location, as well as at the two other treating stations I have referred to, to ultimately treat the sewage in a satisfactory manner, so that the danger from any sewage contamination or sewage menace will be reduced to a minimum, with due economy and results both in mind. The exact plans have not yet been approved for that particular plant, but they are all under consideration, and will be disposed of before many months. If you will remember, about two years ago the electors voted on a levy, agreeing to a tax upon all the property in the city for sewage disposal purposes. That levy extends over a period of twelve years, and it was estimated that it would produce $2,000,000, which is supposed to be sufficient to construct the sewage disposal plants. That is according to original estimates, but those estimates are somewhat disturbed by present conditions, so I cannot definitely say whether that amount will be sufficient or not.

J. A. PHELPS.—Can you give us any idea how long it will take before those plans will be carried out?

ROBERT HOFFMANN.—It is rather difficult to state. I imagine that the first work probably will be done at West 58th street. Simultaneous with that we expect to do some work at the southern plant, because it is quite necessary to keep the contamination out of the Cuyahoga River. The contamination at West 58th street and Cuyahoga River are a source of greater danger to the water supply of the city itself than at 140th street, because of their more direct relation to the

water supply intake. I would say that the whole project ought to be disposed of in four or five years and possibly before.

W. J. Carter.—There is no portion of this $3,000,000 issue to be used in that improvement?

Robert Hoffmann.—This $3,000,000 is supposed to be expended for the ordinary sewer systems, and not to be used in the sewage disposal at those three plants. Those really are financed. As I say, we have authority to sell the bonds. It is simply a matter of time when we will be ready to go ahead with the work, provided the bonds find a sale.

G. E. Tower.—In one of the slides shown, I noticed there were different shapes to the sewers, the circular, ham-shaped and egg-shaped. I would like to learn, if I could, as to the merits of those different shapes, or whether it is more or less of a progress from one shape to the other in the use of the different shapes of sewer construction.

Robert Hoffmann. — There was one point I did not bring out. The theory of the egg-shaped sewer is to give the maximum depth. The deeper your flow is the better your velocity will be. That is the theory of the egg-shaped section, to give a better velocity, and thereby keep your sewer cleaner through this great velocity, by having the depth as deep as possible for its ordinary flow. After you get over a certain size, it does not make much difference. The ham-shaped section was worked out for purposes of economy. You can have a large capacity with a minimum amount of masonry by reason of the arch shape. The shape varies with the depth of flow you must accommodate. You have your high water point to consider as well as your flow line. You must keep your high water point continuous, for which reason we have to change the cross-section of the sewers occasionally.

W. J. Carter.—I think the main point you made in explaining the diagram was the rapidity with which the water reached that sewer, making it economical to have the ham-shaped section in some districts, while the circular section was more effective in other districts.

Robert Hoffmann.—The ham-shaped section was really worked out for minimum costs.

A. F. Blaser.—I would like to ask whether, as a general proposition, it is better to put through public improvements under bond issues or with taxes. I understand, perhaps, that in this case it cannot be done by taxes, but nevertheless if there were leeway in the tax laws to permit financing by increase of taxes?

Robert Hoffmann.—I think it is the consensus of opinion that if we could keep from bond issues we would like to do so, because we have not only to pay the principal, but a very large amount of interest as well. If the sewers and pavements could both be financed by a tax levy, I think it would be by far the preferable way; that is, if a certain percentage of the taxes of the city could be set aside each year for sewer purposes and for paving purposes, and you could actually use that cash as you received it, and put it in construction work, you would save the interest and you could pay as you go; but unfortunately the law is not so that this can be done. A certain proportion of the city's part of the general tax levy goes to the sinking fund, another for the interest on the public debt, which the law requires must be paid first. What is left goes for operating expenses. The total allowable levy is one and one-half per cent and under conditions which Ohio cities are in at present, the one and one-half does not raise sufficient funds. There is no provision that I know of which enables the city now legally to make a levy either for sewer purposes of for paving purposes, which will go outside of that one and one-half per cent limit.

A. F. Blaser.—When the interest and principal on these bonds falls due,

then the taxes we pay must first be used to retire these bonds?

Robert Hoffmann.—I do not see any other way to it, the more bonds you sell the more your sinking fund and interest will be. If the valuation increases sufficiently so as to make up that difference, and your operating amount remains constant, well and good, but if the valuation ceases to grow, then you are approaching a critical period. The only way you can overcome the matter then is to have the legislature change the law so that a larger percentage can be taxed, or else you have to raise in some indirect way a sufficient fund by taxing privileges of some kind, so that you get some money other than by tax levying.

I. E. Waechter.—Mr. Hoffmann pointed out the tax levy is distributed according to the proportion of foot frontage of each lot. Is it just to have the property owner who owns a one-family house, for example on a forty-foot lot, pay as much taxes for sewers as one who owns just as wide a lot who has a six-family apartment house?

Robert Hoffmann.—It might not be just if the only thing we did was to take care of the sewage from those houses. But you have sewers for two purposes, one is to take care of the storm water, and the other to take care of the house sewage. These two overlap and you must make the storm sewer the same size in either case. Then they both have the same privileges. The man who has the two-family house has the privilege of building a four or six-family house. He has the opportunity of getting just as much advantage. As explained, the taxes on the benefit basis are not upon the foot front basis, but as a general thing the benefits can be divided according to the foot front. If a man has an eighty-foot lot, he has twice as much benefit from that sewer as a forty would have. Of course, in all these taxation matters some injustices can be found. The thing is to get them as nearly right and proper as you can. I think in any of the methods which have been proposed for special taxes, some point of criticism can be found where there is an apparent injustice. The sewer tax by the way of frontage tax is very small as a usual thing. At present we are limiting it to $2.50 per foot front. The high prices have made it necessary to increase it to that amount. Anyone who has a forty-foot lot is only taxed $100.00, which is spread over a period of five years, making $20.00 a year. The sewer may last for sixty or seventy years, so when you spread it over that entire period, it is a very small thing.

I. E. Waechter.—There seems to be a tendency towards single tax.

W. J. Carter.—Mr. Hoffmann, under the present method of taxing per foot front for local sewers, suppose the tax so raised is not sufficient to construct the local sewer?

Robert Hoffmann.—The city must always pay for the part of the sewer in street intersections. By reason of different conditions encountered in different parts of the city, for instance in one place it might be rocky and in another place it might be much easier to build the sewers—it has never been the policy of the city to always charge the property what the local sewer cost, but it has been held that property ought to pay no more than for average conditions. This for many years was $2.00 a foot, and recently increased to $2.50 per foot front. If the sewer costs twice as much the city pays the excess cost in order to equalize that matter. The theory is, of course, the city should pay all additional cost over and above what a local sewer would cost.

Engineering and Co-Operation

By Dr. Ira N. Hollis*

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One can hardly speak to a group of engineers on any subject at this time without some reference to that which is present in the minds of all Americans, the war into which we have entered, perhaps the greatest struggle in all history. Under any circumstances, it is the greatest in the cause of freedom and democracy. It is truly a war for the union, in the same sense that our Civil War was a war for freedom and unity.

I have heard it called an engineers' war, but I prefer to put it in another way. It is a war in which engineering training or, at least, the kind of training that is given to all engineers and men in applied science, counts most.

I listened a few days ago to a Frenchman who had come to this country to ask help of Americans by means of certain specialized regiments behind the lines in France. He suggested the need of at least 60,000 men, without any military training, for service behind the fighting lines, and he described the war as an industrial enterprise, rather than the kind of thing that we have always thought of in discussing the war. The organization is essentially that of any great company for manufacture and transportation. This French officer spoke about the immediate necessity for engineers to make arrangements for transmission of power, for communications, for the continuous supply as the English and French surge forward into the country occupied by the Germans. To a limited extent, America has already begun to send specialized regiments to France for railroads, forests and mines.

In this sense, the war is an engineers' war, but in the larger sense it is everybody's war, as it involves the co-operation of every interest in the United States, from the infant to the old man. It is not to be won by the farmers, as some would have us think, or by the mechanics, or by the railroads, or by the soldiers. It is to be won by all of us.

When one speaks of war, the word "co-operation" comes into one's mind as a matter of course. That is the one element of success for an army. Devoted and willing co-operation in obeying orders for this great cause is bound to bring us to a glorious success. It seems to us at present as if co-operation were a new discovery and we hear so much of it that the world seems to have been heretofore poor in that spirit which enables men to work together to a common end. All civilization has been built up on co-operation from the time of the first lonely savage on this earth, through the long period of history that has brought us to the great American democracy. It has all been co-operation; that is what modern life is; so that when we talk of co-operation, we must not forget that civilization bears a direct proportion to the capacity of human beings to work together. In a representative government, that means always the rule of the majority.

There are two kinds of co-operation. The first perhaps is not co-operation at all. It is that kind where the great mass of a nation are more or less forced to work under a privileged class. We are in the habit of calling that autocracy, but it is, after all, the strongest kind of co-operation developed by a few men whose business and power it is to plan for a broad co-ordination of everything within

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national boundaries. I cannot believe that it is the best kind of government, although it does stimulate the kind of intense activity that we see now in Germany, and have seen for the past forty years. In the long run, however, men will get along better where there is a willing surrender of self to the needs of a great democracy like ours. I do not believe that democracy has yet had its fair test on this earth, and the comparison that demonstrates the efficiency of an autocratic empire in war as contrasted with a republic is not based upon a sufficient experience. So long as there is one autocracy left or one nation where a privileged class has the right to arrange the fate of every man and to plot in secret against races all over the earth, there will be no opportunity to determine what democracy can do for a new race. It can never have a fair test until the other kind of government is wiped off the face of the earth.

It is possible to have co-operation gone mad, and there are some examples of it in the United States, wherein the trade unions have banded together to limit the enterprise of the individual. Labor has even gone so far as to put on the Department of Labor Building in Washington, "Dedicated to Labor, Freedom, Justice and Humanity;" as if labor in the machine shops and on the railroads had any more right to freedom, justice and humanity than the rest of us. The motto applies to all of us. The only true co-operation I know of in this sense is the right or power to sacrifice one's self to the nation and to what might be called the social ideals of our country. That is the true liberty and the true equality referred to by the founders of this republic.

We must not forget, therefore, as engineers, when we begin to talk about co-operation, that it is nothing new. The topic for discussion ought rather to be how best to make it effective. What means should be adopted to bring it to something more than simply talk? How can it be applied to engineers in a special way, so that they can be more able to serve their country, or so that they may be more able to dedicate themselves to real service? Few engineers obtain great wealth unless they get out of engineering entirely and go into business or into manufacturing on a large scale. Consequently, I think of our profession as that which listens most willingly to the call of service. You have evidence of that in every state. The only profession I know of that is superior to it in the dedication of self is that of the school teacher or the ministry.

How can this word be made to mean something more to us as engineers than it has meant in the past? We ought not to think of it so much in terms of this war, although God knows that we need all the co-operation we can get to bring us to a successful end; but rather in terms of that brotherhood over the whole earth which will never permit another international difficulty to be settled by bloodshed.

I spent nineteen years in the American Navy, and during that time I do not recall a single American who wanted to see the United States at war for the purpose of testing out the ships and war machinery accumulated for national defense, and I never knew an officer who wanted to fire the guns in anger. I never knew a man in the Navy who did not look with horror upon the prospect of bloodshed and the misery that would have to be brought to every family by war. Consequently, my chief hope is that through co-operation of exactly the type that the engineer is capable of exhibiting, we may solve our difficulties in the future between nations without war and without bloodshed.

Engineers have always worked together more or less. We call this an age of specialization in connection with engineering, but what is special-

ization but co-operation? "Everyone to his trade" is taking co-operation for granted, and success is dependent upon it.

I want to say to you gentlemen tonight before I go into this subject that it is comparatively unimportant how co-operation is brought about amongst engineers, whether it comes through national engineering societies, through local engineering societies, through clubs, through colleges, or through the efforts of individuals in different parts of the country, so long as it is effective. If engineers can be made to recognize themselves as members of a great profession with exactly the same interests in serving the country, the incomplete efforts in the past, and various conferences and discussions to bring them all together, will seem but imperfect beginnings to us. The war has provided a psychologic moment when everything can be accomplished, because attention is called to our combined effort as the important thing toward the future. It will also be the most important thing in the readjustment of peace after this war is over, when every industry will have to get back to normal conditions.

There is a certain kind of misunderstanding about the national societies bred in the west, where the members believe that the activities of these societies are confined too much in New York. As a matter of fact the societies in the Engineering Building in New York are as keenly alive to the needs and wishes of engineers throughout the country as Congress is. I have served on the Council of Mechanical Engineers, and I have never heard a word that would seem to indicate in the Headquarters the slightest desire to sidetrack local interests. The whole history of the society proves the contrary, in the development of sections all over the country. There are 21 or 22 such sections and the chief thought of the Council is to give them every possible scope. Of course, it is plain that, in making up committees for any national society, the men who are available must be appointed, and where a society is spread from coast to coast, it is impossible for a man living in California to serve with a man living in New York. It cannot be done, unless the subject to be taken up by the committee lends itself to development by correspondence. Consequently, when the national societies appoint committees, all members must be within reach of New York. The national societies are not managed by comparatively few men. Anyone who indicates that he can be useful, will find a place; it makes no difference where he is. Any member who is active-minded and shows a capacity for promoting the causes for which the society stands, must thereby establish a place for himself. It is, after all, the old principle that *a member gets out of an association what he puts into it and more.*

One of the methods of giving societies a more national standing is through the sections. We have, in the American Society of Mechanical Engineers, made a great effort during the past few years to interest groups of men, and we have gone so far as to obtain from them even the nominating committee for the officers of the society. The candidates for office of this year were all of them named by men suggested from geographical sections all over the United States. It is my theory that engineers in any locality ought to belong to two engineering societies, one a national society, and the other a local society. In the case of the national society, an engineer can be affiliated with the one most directly in his own specialty. In the case of the local societies, all engineers without regard to specialties or affiliations ought to come together, for acquaintanceship and for common action as citizens in relation to local affairs, even of legislative matters.

A number of years ago I was presi-

dent of the Boston Society of Civil Engineers, and we made a special effort to bring the representatives of all societies together. A committee was appointed to see what could be done about it. The result seemed at first disappointing, because the conditions worked more to strengthen the sections of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, but, after all, the main end was reached, because the Boston Society of Civil Engineers and the two sections mentioned have worked together like brothers in the profession ever since. Besides that, the Boston Society of Civil Engineers has since grown from 600 to 1,000.

Your own society here in Cleveland is a first rate example of what I mean by a local society of engineers. When you take part in the good government of the City of Cleveland, you are only fulfilling your obligations as citizens, and your engineering society not only has a right to take that part, but it has a duty to see that all that relates to sanitation, streets, transportation, and water supply are properly safeguarded. The only thing is to extend your society to the entire state, either by having it reach out to every part of the state or by affiliation with other engineering societies; so that you may have an Ohio State Engineering Society. Personally, I believe that the very best can be done by a union of a large number of local societies, just as I believe that the best government is based on local autonomy in sections of the country under one glorious flag.

There are several methods by which the engineers can be brought together into better co-operation:

(1) By means of a congress of all the engineering societies, to which a number of representatives shall be sent with power to commit the societies within limits.

(2) By means of a conference called from year to year for the purpose of recommending lines of common action to all societies.

(3) By means of a council beginning with a few societies and gradually extending itself into a nation-wide senate, with power to speak for the engineers along defined lines.

(4) By organizing in every state an engineering society composed of the smaller groups in the cities, having some national central congress to represent all the state societies.

While the engineers have had special conferences of all kinds and on all subjects, not one of the above four methods has ever been thoroughly tested. It has seemed difficult to bring even two societies into agreement. The third of these methods seems to me the most promising, inasmuch as it provides for gradual development, which should lead to the fourth method of holding the engineers together. The Engineering Council now being tried in New York represents the national societies of Civil, Mechanical, Electrical and Mining Engineers. It is in their name that the Engineering Building at 29 West 39th Street, is vested through the United Engineering Society, which is incorporated for holding property. In discussing closer union amongst the engineers, it seemed better to use an existing organization and to create, for the time being, committees of that body. The Council is, therefore, a committee of the United Engineering Society, but its by-laws permit the addition of other national societies than the four above named. There has never been any thought of excluding other engineers, as the holders of the Engineering Building regard themselves simply as trustees for the engineers. The Council has the power of speaking on questions common to engineers. It held its first meeting in June, and has thus had to contend with the summer months in perfecting an organization and doing business.

It has been difficult to bring the

members of any national society to the thought that great public questions form any part of its function. For instance, the A. S. M. E. was founded by a small group of men whose chief intention was the interchange of papers on technical matters. It was a society, therefore, for the education of its members. In the gradual development of the past 40 years, during which Mechanical Engineering has changed very much, the Society has been forced to take on new duties, in order to keep up with the times. Public questions have come forward in relation to the development of power, to manufacture, to transportation, creating practically a new profession, and the society either had to disappear or assume responsibility for public relations on a large and generous scale. The same statement applies equally to the Civil Engineers, the Mining Engineers, the Electrical Engineers, and to all other Engineers. The consequence has been a broadening out undreamt of by the founders, and with that broadening out has naturally come the spirit of co-operation. Taking, for instance, the relation of societies to the public, we very quickly find that all societies have a like interest, so that a council or a senate is a necessary body in enabling the societies to work together. It amounts to a clearing house to enable engineers to understand one another and to make a strong, united sentiment on great public questions.

The more the engineers study public questions, the more derelict we seem to have been in the past. As a matter of fact, our profession lacks in citizenship, because we have confined ourselves too much to technical problems. We have been too long content to occupy subordinate positions in the civic life of the nation.

What are the great public questions at the present time? The first relates to commercial standards. There is nothing more important in enabling our country, after this war is over, to hold its place in the modern world. A committee of the four societies mentioned has already been formed to stimulate and encourage standardization. The Society of Automotive Engineers has done splendid work in this direction. It is hoped that the new standardization committee will include a large number of societies. It will certainly have representatives from the government as, for instance, the Bureau of Standards, the Army and the Navy. Its functions will relate to the acceptance, or promulgation of new standards. The standards themselves must necessarily grow out of commercial practice and must be established by the men who are most familiar with the commercial demands.

The second involves the great national question of coal saving by means of water power, by reduction of waste, and by increase of efficiency. Up to this time, our Congress has held back from development of water power on all public lands and has thereby rather encouraged the wasteful expenditure of petroleum and coal. All engineering societies are interested in this in one way or another.

The third great question is concerned with research on a great scale for peace and war. A large number of groups in colleges and in societies have been formed to conduct special kinds of research, but there is much overlapping, and this is a public question involving broad co-operation.

It would be possible to name a large number of activities undertaken in spasmodic fashion by individual societies, and yet which are common to all. If the newly organized council can develop contact with all of the engineers of the country and thus create a thoroughly democratic body, whose work extends to every field common to the engineering profession, it deserves zealous support. If it cannot, it should give place to some other body. Our country is peculiarly dependent upon the willing co-opera-

tion of individuals and of societies. In a nation like Germany with an autocratic government and a social caste which predominates over the individual, co-operative movements may be forced, but in our country, where every individual has complete freedom to develop himself, nothing but willing sacrifice of selfish motives will enable us to make of this country all that it deserves to be.

It has been suggested that the engineers as societies cannot go into politics. That is true, and no organization, whether it be engineering, legal or medical, ought to go into politics, so far as partisanship is involved. We cannot support a man because he is a Republican and we cannot support him because he is a strong advocate of the trade unions, but we can enter the legislative field in the interest of the entire country. Legislative matters connected with water power form a perfectly legitimate subject for activity among engineers and engineering societies. It may be said that the local societies can be more effective in relation to Congress or a Legislature than national societies. Furthermore, it is more natural for local societies to take part in the acts of State Legislatures and City Councils; but there are a large number of interests in which the great national societies can act together and can be very influential in informing Congress on matters of importance to the country.

I cannot here speak for the Engineering Council, but I can express the hope that ultimately all engineering societies will come to believe that it is their duty to take a hand as societies and as citizens in everything that is for the good of the country, provided always that partisanship and selfishness are completely routed out of common action.

It has been suggested that we ought to form a completely new society of engineers, or, as one of our eminent members has said, "a civic association" to enable us to speak on national subjects. However useful this new association might prove, I do not think it is at all necessary, as we already have the machinery for common action, if we can only get together. One of the difficulties in recent years has been the multiplicity of organizations. A new association is formed almost every day. The difficulty in Washington now is that a large number of voluntary committees exist, without the means of co-operation or united action. A new society of engineers may ultimately be necessary, but I firmly believe that it should be the outcome of at least an attempt at united action.

In forming a senate of engineers, there is no reason whatever for destroying the autonomy of engineering societies. Indeed this autonomy ought to exist, as there are many broad fields of activity that cannot properly be undertaken by one great society. A glance at this subject indicates at once that mechanical engineering, civil engineering, electrical engineering, mining engineering, automotive engineering, chemical engineering, have definite fields, and the societies are better with the limited organization necessary to work in each of those fields.

The suggestion that we ought to have one great society with a section for each of these groups does not seem to meet modern conditions. A senate recognizing each society is like the central government based upon local self-government by every state. It seems to me possible, therefore, to organize the engineers exactly as our country is organized, and that the ultimate outcome of a council such as that recently formed must necessarily be a larger council composed of representatives from national societies and from state societies. This idea is not new, but it should be pushed. The Chamber of Commerce in Washington is something of this kind, and the referendum which they are in the habit of sending out is easily adaptable to the needs of the engineers.

A better organization of engineers all over the country is also a war measure. At the present time we are forming a national army in which men are selected for the duties that they can best do. This type of service must prevail in every direction. We as engineers must contribute not only to the best of our abilities, but in the direction for which our training has fitted us.

The Engineering Council formed as its first committee one on service. Mr. George J. Foran is chairman, and the other members are Mr. A. D. Flinn, Mr. George C. Stone, Mr. A. S. McAllister, and to these is added Mr. Sturgiss, who represents the chemical engineers. Letters have been written to other societies and representatives are welcome, inasmuch as it is a personnel committee for all engineers. The first duty of the committee related to the assemblage of information for immediate use, and to that end the names of about 3,000 engineers of special training were obtained from a number of engineering societies. These names have been tabulated and are easily made use of for detailing men to various branches of the government. A number of calls have been answered and Mr. Foran's committee is accessible to both the Army and the Navy.

There has been some discussion as to the utility of a census of the engineers. Many questionaires have been sent out which, to some of the older men, seem more or less superfluous, and yet a good directory of all the engineers in the United States would be immensely useful at the present time. If this records the specialties of every man, it would be useful in the time of reconstruction after the war is over. I cannot speak for the Engineering Council, but I can speak for myself in expressing the belief that a directory of engineers ought to be used as part of an employment office for the industries and for our profession. The country has heretofore been weak in the classification of professional men and laboring men. Anything that would enable a young engineer to locate himself where he could be most useful, and where he could make a living, would add to the value of our permanent organization in New York.

Many questions are coming up from day to day which should be answered either by committees or by the help of committees in procuring men to supply the answer. The great problem today, involving also our descendants, relates to the saving of coal. Many committees are forming. Few of these consist of engineers and the government is making a serious mistake in committing the coal question wholly to business men, on the thought that it is simply a business question. As a matter of fact, the engineers by their training and by their experience are more capable of dealing with the coal problem on a great scale than any other class. Our chief difficulty, however, is to make it plain to the government that the societies are willing and capable of taking up scientific, war and general questions. I have already referred to the water power which is now confessedly an engineering problem.

Going back to the Engineering Council, to my mind we have the greatest opportunity that the engineers have ever had in the history of this country. All of us should get together to make our strength felt. One of the reasons why our profession has been treated more or less as a trade and its members are considered wage-earners like any other laboring men, is that we have not expressed ourselves well as to the ideals of the profession. We are content to go along doing our duty as technical men, too often without thought that we have the same power to influence civic affairs as other citizens. A union such as that made possible by an extension of the Council will enable us to teach young men coming out

of college and our neighbors as well, the value of engineering service and the demands that those who practice the profession shall be highly trained men of broad education. I do not believe there is any difference of opinion on this subject. Often the main trouble with us is that we differ too much as to method and our efforts are rendered more or less ineffective for that reason. It will not do for every individual to go off by himself. Today we have proposed a Civic Association of Engineers, a conference on Co-operation, an American Association of Engineers, an Academy of Engineers, all going in different directions, and no two working together. It might be said that the Engineering Council is only another one, and yet it differs in one important respect; that it is based upon existing organizations, and has the power within defined limits to speak for them.

A method of extending the engineering influence and of making it nation-wide has been suggested in numerous letters that I have received. It is to take the five men designated by the four engineering societies and the Chemical Society to make the industrial inventory under Howard Coffin two years ago, and to constitute them a nucleus about which an organization can be formed in every state; but organizations already exist in many of the states, and it is not necessary to take in five men as a nucleus. In Ohio, for instance, you need only a good society in Columbus to be able to complete a first-rate state-wide organization. This society in Cleveland is one of the best in the country, and with others like it you can speak better for Ohio than any society of men could speak in the next generation, if newly organized for that purpose. The same thing is true in Chicago and I may say for a number of the more populous states. There are some states, however, where it would be of advantage to begin with the five men suggested and to begin a new engineering society. You see that I am thinking of a democracy; not thinking very closely perhaps, because we do not know how our present Council is going to work out.

Sometimes I think that we emphasize the word "co-operation" too much. What does it realy mean? We may take a lesson from Prof. Jaques' article wherein he begins, "For God's sake, shut up!" Talk never produced co-operation, and we have a tendency to do too much talking without really working together. I have sometimes thought that standardization is the hand-maid of co-operation, because through it the industries and the engineers learn to look at things from the same point of view. The best method of promoting co-operation amongst societies is to undertake some problem and to put it up to each one of them to do its share.

In connection with the work of Mr. Foran's committee referred to above, I fear there has not been enough publicity, as the committee has been anxious to do something without talking very much. They have listed all the societies and have obtained complete data about every engineering society in the United States. The best method of making a directory of the engineers is not easily determined. It is possible for the national societies to send out questionaires, but probably completer results would be obtained by appealing to all local societies, inasmuch as we want the non-members of all societies, as well as the members. We want the non-graduates of engineering colleges, as well as the graduates, upon our list. A card catalog made out as the result of tabulation ought to be in two places; the complete card catalog in New York, and the local card catalog in the hands of the local society. I refer to New York because it is there that the Engineering Building is located.

One example of the possibility as to thorough co-operation is found

in the discussion that took place in Cincinnati last May during a meeting of the A. S. M. E. and the Machine Tool Builders' Association. We had a session on munitions, and the manufacture of munitions for the Army and Navy. Before the war very few industries were willing to interchange information, but since the declaration of war, this interchange is almost a necessity. It should be continued, and some kind of a trade paper or trade circular ought to be published, giving everything that would be used in promoting our industries. That is what I call true co-operation, and that is what I call true patriotism. Let us get rid of foolish, narrow methods that sometimes impede progress. The old days when every manufacturing firm had its own peculiar screw thread are gone by, much to the benefit of our commerce. The same thing will be true of most of our products in the course of time, and future manufacturers will look back upon this period of foolish competition as a kind of barbarism.

It would be possible to dwell indefinitely on this subject, but I might ask you here, in conclusion, one question. Do you think that the engineers of this country are not ready to work in harmony? There is not a member of our profession who does not know that we want to work together; there is not one who has not confidence in all the others. My own experience leads me to believe that the engineers are the most united body of men on earth. They have had to strive to make their places, they have had to work hard to convince the world of their value, and they have that fellow feeling that comes from companionship in the work of the world. The one thing they lack is a better understanding of organization and greater ability in bringing it about. I referred to difference of opinion as to method. One of the most curious committees I have ever seen was made up of men who agree absolutely as to everything, and yet were comparatively ineffective, because every member had his own peculiar method which he could not adjust to the thoughts of the others. Let us get rid of that by trying over and over again to bring about a better understanding through the Council, through a congress of engineers, or through a completely new society.

I have emphasized the word "co-operation" and that is what we must keep before our minds. We are wage-earners, of course; so is the lawyer and doctor. The fact that the lawyer is able to get an exorbitant fee out of a distressed firm does not make him more of a professional man than the engineer, who gets his fee for benefit rendered. Let us make of co-operation something real and active in the service of our country, now and during the long period of peace that must follow war.

DISCUSSION

J. C. Pinney (President, Engineering Society of Wisconsin).—Dr. Hollis has brought out so many good points, each one of which is worthy of deep thought by all engineers, that it is somewhat difficult to discuss his paper without making such discussion much more lengthy than the paper itself. To avoid any such lengthy discussion I shall confine my remarks to that form of co-operation which Dr. Hollis mentions as Democracy—that form in which the individual *willingly* surrenders his personal interests for the common good. Democracy, however, means more than merely this individual surrender of one's personal interests. It means that in return for this surrender the individual should and must receive from such democratic movement a helpful co-operation and a voice in the co-operative and democratic movement equal to that of his neighbor, and one that will make him realize that he is an integral and necessary

part of a whole. Such democratic co-operation is exemplified in our own form of government under which we enjoy a degree of liberty and freedom coupled with a feeling of personal responsibility unknown to any other people on earth.

But how is this to be secured for the thousands of engineers among our own professional brothers? Dr. Hollis mentions four methods, viz.:

1st. A congress of delegates clothed with certain powers to act.

2nd. A conference of delegates to recommend action.

3rd. A council beginning with a few societies and expanding.

4th. A central congress of state societies through which local societies are represented.

Of these four methods two are already being used, the second and third, and if democracy is in fact the best example of true co-operation, and I think we all agree that it is, these movements must both be able to stand the test. That movement which cannot stand the test of true democracy should *willingly* give way to one which can. The two movements which seem to be making progress along the lines of co-operation are the Engineering Council of the United Engineering Society and the Conference on Engineering Co-operation. Both of these movements have been launched and each of them has as its object better co-operation among engineers, using the existing engineering societies as a basis. How do they compare as to democracy?

In the first place the Engineering Council in its by-laws provides that the representatives of the four founder societies "shall be designated by the governing body of such society." A truly democratic council would certainly let each co-operative unit decide for itself the method of choosing its delegates. I will grant, and, so far as I see at present, would favor, the proposition of having each society entrust its governing body with this selection, but let the individual societies themselves, and not the council so created, decide this matter.

In the second place the council excludes *forever* the entrance for co-operation of all societies other than *National Societies,* thus effectually barring all state and local societies. This clause cannot be changed without amending the council's by-laws and there is no provision, to my knowledge, for amending these by-laws.

Last, but not least, the by-laws of the Engineering Council provides that the expenses of the council shall be disbursed from funds provided by the Trustees of the United Engineering Society. This places the control of the council in the hands of these trustees. If for any reason these trustees should decide to effectually throttle the council, no power on earth can hinder them. If for any reason these same trustees should, as provided in the by-laws, decide to admit another "National" society not represented in the United Engineering Society, such new member would enjoy the distinction of having "Representation without Taxation". To me this would be as repulsive as Taxation without Representation.

Let us compare with this the Conference on Engineering Co-operation.

1st. It is composed of delegates from *all* engineering societies which desire to be represented, and these delegates are chosen by their respective socities as each society deems best.

2nd. Any society, local, state or national, is not only welcomed but urged to be represented. There are no bars.

3rd. The expenses of this conference will be borne in such manner as the represented societies through their delegates or otherwise, determine.

Which of these two movements, I ask you, is truly democratic and really co-operative? Which movement requires a willing sacrifice and in return offers a just reward?

Dr. Hollis says, "If the newly organized council can develop contact

* * * and thus create a thoroughly democratic body * * * it deserves zealous support. If it cannot, it should give place to some other body." I most heartily agree with Dr. Hollis in this statement, but, as I see the by-laws of the council, this democratic development is forever limited to the national societies. I say "forever" advisedly, because there is not only no provision for amending these by-laws, but this plain provision for making further rules is inserted as a part of the by-laws, "The council shall have authority to make rules for its own guidance *not inconsistant with these by-laws*." Personally I can see no way by which the council can develop the democracy so much desired by Dr. Hollis and the rest of us except by discarding the present by-laws and adopting a new set which practically amounts to dissolving and reorganizing.

In conclusion, allow me to state that I firmly believe that the great national societies are the ones best equipped to start this co-operative movement. They are the ones through whom most can be accomplished if they launch a truly democratic movement for co-operation. The council which they have organized, however, is not the only one based on existing organizations, as the Conference on Engineering Co-operation is absolutely and entirely based on existing organizations and is composed entirely of delegates therefrom. I have endeavored to show where the Engineering Council is not and cannot be truly democratic. If I am mistaken in these views I earnestly desire to be corrected, as I am only seeking a truly democratic and really co-operative movement, and when such is started I desire the opportunity to put my shoulder to the wheel and help push it along.

A. F. Blaser.—The question of co-operation among engineers has always appealed to me. By what means this can best be accomplished I am unable to say for I am not familiar with plans that have been proposed. But there can be little doubt that if the need for organization and co-operation were universally felt among engineers the method by which it could be attained would not be long delayed.

I prefer, therefore, to limit my remarks to a few points in Dr. Hollis' paper which relate to the desirability or advisability of better co-operation. Co-operation resulting from a long felt need might well be illustrated by the phrase, "Co-operation gone mad." This phase is exemplified by trade unions and the results are not always gratifying as intimated in the paper. But it illustrates as nothing else can that co-operation and close organization can be effected where the need exists. No one will deny that the members of these unions can and do accomplish aims which as individuals they could not accomplish.

Is there a real need among engineers, which of itself will guarantee a large and strong organization?

There is always danger of being more or less justly accused of selfishness when this idea is brought out too prominently, but unless there is a strong demand for better co-operation we will either be individual engineers or at best smaller groups of engineers.

The primary aim, so far expressed, is that we hope by co-operation to bring engineering upon a higher plane, to get the public to recognize engineers as professional men. Perhaps this is too general and vague and will not appeal strongly to the less active members of local societies.

To my mind it means first of all that we must be willing to assume and accept a larger share of public responsibility. Municipal, county and state governments deal in large measure with public improvements essentially engineering in character. Yet as a rule engineers are not "Prime Movers" in these projects. They are usually content to design, estimate and

recommend. Have we a right in our passive attitude to expect better recognition from the public? The public loves a fighter and usually recognizes one when he appears.

In a wider sense this is the essential principle of democracy. Every citizen, engineers included, must take an *active part* in government. And while it may be true, as Dr. Hollis points out, "That democracy has not had a fair test on this earth," it is equally true that in order to insure its success we must get engineers to come out of retirement and contribute their just part in a public way.

I am well aware that in a measure this is confusing cause and effect. We are seeking a common purpose in order to establish a strong organization. On the other hand we want a strongly organized body in order to insure concerted action in public matters.

It is immaterial, we must educate while we organize and we must organize while we arouse a desire for broader fields of action for all engineers.

E. S. Carman.—These questions have often been asked: Along what lines should engineers co-operate? Should their co-operation lead them to enter problems political or should engineers, as an organization, refrain from entering politics? Should their co-operation be only for the furthering of engineering as applied to the arts?

It seems to me that the co-operation, which we look forward to, should not be confined to a predetermined program, but that when necessity demands it should not only consider all the problems of engineering as applied to the arts but when it is apparent that the public at large can be benefited by an engineering viewpoint on questions political, then the engineers, as an organization, should not hesitate to consider political problems and make public the conclusions that have been reached.

Dr. Hollis has so ably presented the subject of "Co-operation" that there is no doubt in any engineer's mind as to the desirability of engineering co-operation. Therefore, in our discussion, let us accept at once the fact that engineering co-operation is not only necessary but that the engineer's failure to do so would not alone be an individual but a national calamity, for, as never before, the engineer and his work is in universal pre-eminence throughout all the civilized nations of the world.

Therefore, since we have determined that the need of co-operation exists, let us then turn from our survey and proceed, as in all problems of engineering, to the next step—the design or plan of the machine necessary to accomplish. As Dr. Hollis has said, several designs or plans have been suggested by several different organizations; again following the principle of engineering, our next step is to select the best design and proceed to perfect the detail, after which the building and operation of the machine will quickly follow. The problem now before us then is deciding on the design or plan.

It is obvious, as we proceed, that we cannot go further without a Chief Engineer, as some one must take the responsibility for deciding upon the design or plan to be adopted. Therefore, the engineering profession at this present moment is looking for an engineer—in the broadest and fullest sense of the term—a leader, a man of vision, of action, of accomplishment, one having the confidence of engineers, without which success cannot be attained; for, as was stated at the last Chicago conference on "Engineering and Co-operation" that co-operation and confidence are synonymous terms.

The engineers are now ready and waiting for such a leader, or group of leaders, to come forward at this time and invite all the engineering societies, both national and local, to appoint and send delegates to a general conference, such delegates to have full power and authority to commit and bind their society to the united action of the conference. The purpose of

such a conference would not be to discuss the need of co-operation but to decide upon the ways and means and the organization through which co-operation may be accomplished.

Let me again state that our greatest need at present is action, and in conclusion, my opinion is that the proposed organization could not possibly consider an organization that would not include the many excellent engineering societies now existing throughout the United States.

C. H. Crawford (Nashville Engineering Association).—We have talked about "Co-operation" and talked and talked—which reminds me of a story.

A long time ago a drunken engineer straggled up to a table where a few of us were experimenting to find the power required to lift silicious vessels from calcareous surfaces, wrathfully looked the crowd over and said, "You talk and you talk and you talk; you talk about your accumulations, but all that you accumulate is talk."

We are all seeking a workable plan of co-operation. If for any reason we are going to do anything at any time, let's find out just which, if any, of the many vehicles already in running condition is going to answer best and then see that it functions. In the meantime why do we not stop some of our rather thinly-drawn discussion over codes of ethics and adopt one; it may not be a good one but, once adopted, holes soon will be found and can be plugged.

This war is renovating ways of thinking more swiftly and drastically than it is remaking maps, and the lessons on working together we preached, but wouldn't practice, are being administered to us butt first; people whose interests are mutual are natural friends and by working together can accomplish things toward which as individuals our outworn politico-social theory of "every fellow for himself and the devil catch the hindmost" would not point their wildest dreams. Most everybody except us engineers has learned that *caveat emptor* with all that it implies is as dead as the dodo.

"The engineer should keep out of politics." Did you ever talk to any of the best and most honored men in the profession—men like Dr. Newell, for instance—and hear them tell about the difficulty of holding the attention of some senator or congressman to matters of national concern after a labor leader has appeared in the offing?

We have talked a great deal about co-operation and its difficulties. Who are the difficulties and what are the difficulties connected with eliminating the difficult?

Personally, I believe that any plan of co-operation or amalgamated action which does not recognize the importance of including all local engineering societies will have ignored in its incipiency one of the most potent of available result getters.

Isham Randolph (Consulting Engineer, Chicago, Ill.).—I have read with interest the paper presented to the Cleveland Engineering Society by Dr. Hollis, President Worcester Polytechnic Institute. His theme is "Engineering and Co-operation." A worthy theme for consideration by all engineers, individually and collectively.

The world sees co-operation today on a more stupendous scale than was ever attempted before. The Germans, the Austrians, the Turks and lesser peoples are co-operating to give the Germans world domination. And the English, the French, the Italians, the Canadians, the Australians, the Americans are co-operating to crush the ambitions and stamp out the savagery of the Central powers. Russia, through internal dissension and strife, has for a time withdrawn her strength from the cause of righteousness espoused by the Entente alliance.

The dominant desire of American engineers is to co-operate with the forces working to make "democracy safe for the world." Co-operation must not be debased into the plane of cant phrases, high-sounding but

meaning nothing. It means working together for the accomplishment of a purpose desired by those who combine their efforts. It matters not whether the combination is of individuals or of organized societies. Dr. Hollis cites the co-operation of the four senior National Societies as an evidence of the fact that this spirit is a growing inspiration in the world. The citation is a good one and we look for results which will help each of those organizations as such, and redound to the benefit of each member enrolled in either society. Some of us belong to several engineering organizations. It is my privilege to belong to four of them and my pleasure to be loyal to each of them. Of these societies, the last one to enroll me is a national organization, the youngest of them all; but its young life is full of hope, of vigor and of usefulness. It is a very catholic organization, taking into its fold any and all of those who practice the arts and sciences upon which civil, mechanical, mining, electrical and aeronautic engineering are based. Should science offer a new field of discovery and practice germane to engineering, those who enter that field will be welcome to the fold of the American Association of Engineers. Its basic tenet is co-operation, unity of purpose and of action for the benefit of the individuals and of the schools within its membership. Its standard of morals and of professional ethics conform to all that is best in practice and tradition in the older societies. Helpfulness is its aim and is also its accomplishment.

What, it may be asked, brought this organization into being? Has it a field of recognized usefulness? It came into being to supplement the work of the older societies; to hold out the helping hand to the young men who are just starting on their professional life, who have not gotten far enough along the road to gain entrance to those older societies; the gauge of professional attainment which is set by the senior societies has not been reached by these new men and our junior society reaches out a helping hand to encourge them to that persevering effort which will carry them on to eligibility for any senior membership. Nor is our organizaton one of juniors only; older men appreciate its purposes and they cast in their lot with us to further those purposes and the boy in his appreticeship to engineering touches elbows with the veteran, and fellowship and help comes from the touch. The veteran feels the inspiration of youthful enthusiasm and the boy feels that he has gotten next to the *real thing*. The organization has its social side and friendships are formed through the gatherings for discussion of topics of common interest or for purely social intercourse. Then there is the practically helpful side, through which he who needs a job is brought into communication with the man or corporation who needs his help.

Our Secretary puts this feature of the organization so clearly that I quote his words: "We have a clearing house which we find of the greatest value in a direct way, to every member from the highest consulting engineer to the rodman or the tracer.

"The clearing house of the A. A. E. furnishes information and introductions so that one engineer may gain the technical assistance of another one; introductions so that the financial men may come in touch with several qualified consulting engineers; experienced men for the company needing a staff of engineers, as well as hundreds of positions for the members who need employment."

The duties of citizenship are inculcated, and a proper participation in politics is encouraged. Through a committee on legislation proposed legislation is vised and its bearing for good or ill upon the Association and its members is brought before the members for information and for action should such seem desirable or practicable.

Thus the American Association of Engineers stands before the public as a co-operative body along practical and successful lines.

F. H. NEWELL. (Urbana, Ill.).—Dr. Hollis' address on "Engineering and Co-operation" calls attention to the many efforts which are being made at the present time on the part of engineers to secure greater efficiency in their technical or professional societies. That there is a growing restlessness is shown by the frequently expressed thought that somehow the engineers as a whole are not doing their part as leaders in the world's work and that this condition is the result of the fact that they are not organized effectively for service to themselves and to the community. It is true that there are now many organizations and that others are being formed at short intervals. Most of these follow along the established lines imitating older organizations and perpetuating outgrown methods to the neglect of the larger present needs of the members.

Emphasis has been placed by Dr. Hollis on the new Engineering Council organized by the United Engineering Society and the hopes that ultimately it may speak for all engineers. At present it has no funds and is rigidly limited in its functions—being narrowly restricted by the necessity of conforming to the ideas of each of the four societies—civil, mechanical, mining and electrical—any one of which has practically a veto upon its action. However, Dr. Hollis has expressed the hope that this new body, organized in June, 1917, may grow and burst the present bonds, bring into membership not only other national societies, but local as well.

The Engineering Council is not alone in the field for prior to its formation and possibly as an inciting cause for its organization has been the annual conferences called by the Committee on Engineering Co-operation. The latter is a purely volunteer organization designed to afford opportunity for discussion by representatives of independent societies especially of those things which lead to greater efficiency in the work of each society. Its object is to stimulate discussion of ways and means by which to promote the welfare of engineers in the present societies.

There has also come prominently into view the American Association of Engineers, with its chapters formed, or about to be formed, in various centers of population. This is trying to attack the problem from the opposite standpoint from that of the older national societies. It begins with the welfare of its members as men and from this leads up to the consideration of materials, their strength and uses.

More than this is Dr. J. A. L. Waddell's proposed American Academy, the bill for the incorporation of which has passed the Senate of the United States and is now before the House Committee on Judiciary. The special function of this body, speaking as a representative of the older engineers, is to advise the government on engineering questions.

The project is also being considered of trying to organize or bring together the public service engineers, that great body of men who are devoting their energies and lives to the public service—federal, state, county and municipal, and who it is shown by the report of the Special Committee of the A. S. C. E. is the most scantily rewarded of any group of engineers.

Other proposed organizations might be named, each designed to meet some phase of this growing desire on the part of engineers to get together or to co-operate for more effective service. The question which Dr. Hollis endeavors to answer in part is as to what is the cause of this unrest and what are the big things which are to be accomplished. The reason is evident, namely that our present organizations as compared with modern

business ideals are conceded to be relatively inefficient. While we have been studying efficiency in the organization of mills, factories and contractors' plants, we have neglected it in our own affairs. It is a case of the old adage where the shoemaker's wife, etc.

In what particular respect is it seen that the present engineering organizations are not effective? It is primarily because they do not meet the larger needs of the great body of its members. It is a curious anomaly that the larger and more powerful the organization the less it is doing for its members. In contrast, the poverty-stricken small local organizations are often serving as the greatest stimulus and aid to the younger men who have most need. Why is this? The reason lies in the fact that the larger, more wealthy organizations while theoretically democratic are essentially aristocratic, using both of these words in their original meaning and not in any derogatory sense.

"Aristocratic" originally signified the kind of government which is denominated by the "best people" or by the relatively few who are recognized as wisest and most influential. The constitution and methods of procedure of most of our older societies have been so developed as to keep the control in the hands of the relatively few most widely known and highly respected men. This is done under the proper assumption that such persons as heads of great engineering works or institutions are the men whose vision should guide the destinies of the society. But the great body of the members—80 per cent more or less—are essentially wage earners! They are expected to be content in being admitted to the organization and to vote for the conspicuously able few. Having no means of personal contact or discussion with each other they naturally turn to these best known people and yet at the same time feel that the organization conducted by these leaders who are often employers is not one which is doing for the rank and file the things which they most need.

On the other extreme are the small local societies thoroughly democratic in methods where these younger men can meet, become acquainted, and discuss matters not only of technical but of personal interest. There inspiration is received from the frequent meetings and from full consideration of matters of immediate concern as well as of professional importance. These smaller societies in order to perform this important work effectively need the stimulus of occasional meetings and of exchange of ideas. It is for this reason that the conference on Engineering Co-operation is so important and why in working out more comprehensive plans the engineers must not neglect to conserve and promote the local autonomous bodies—each working out its salvation in its own peculiar way.

The point to which exception may be taken in Dr. Hollis' article is his statement of the great public questions which at the present time confront engineers and on which we have been notably derelict. He gives them as follows:

a. Commercial standards.

b. Saving of coal by the use of water power.

c. Research.

While it is true these are great public questions, they can hardly be considered as great questions neglected by the engineering profession. They directly concern relatively few interests and moreover they are already being considered by well-organized bodies. For example, the question of standards is one to which the U. S. Bureau of Standards is devoting its millions of dollars of appropriations and to which several engineering organizations are giving specific attention.

The saving of coal by the larger development and use of waterpower is a matter more largely of economics

rather than of engineering. All are agreed that water power should be developed and used as rapidly as possible but such development depends upon the ability of the promoters to demonstrate to investors the benefits of the investment and also to secure from Congress more favorable terms or better laws than those now governing the use of water of navigable rivers or of streams flowing across national forests or other public lands. The engineers are ready to do their part when these economic and legal questions have been determined.

The third of Dr. Hollis' great public questions is that of research and here also the National Research Council created by the National Academy of Science already has entered upon the field and is collaborating with many laboratories, public and private. While engineers can and should aid in this movement it is not distinctly one of the questions which is being neglected.

If these are not the great public questions of the present time—on which engineers have been derelict, then what are they? What is it that is giving rise to this restlessness among engineers—as shown in the attempt to create new organizations and modify existing ones. The unsettled questions of greatest import are those which reach deeper or more intimately into the life of each and every engineer. They pertain primarily to his very existence and status in society and may be summed up under the following heads:

First. Employment.
Second. Publicity.
Third. Legislation.

The first and most fundamental or far-reaching is that of the conditions of employment. The engineer, no matter how highly trained or educated, is of practically little use to himself and to the community unless he can secure work where his services are of most value. While we all recognize this, yet the somewhat anomalous condition has existed, that because of the intimate relations to each of us there has been a hesitation to approach the subject; a fear of lowering the dignity of the profession or of incurring the charge of commercialism. Thus few engineering societies have ventured upon a full study of the subject. The American Society of Civil Engineers had a special committee which after several years produced a report revealing some surprising conditions and showing that the subject involved many difficulties and possible embarrassments to the society. One or another organization has tried in a more or less desultory way to advertise the fact that some of its members are seeking employment, but so far as known there has been no systematic study and analysis of the situation such as is creditable to the engineers as investigators and executives.

We know practically nothing concerning the character or condition of men who are properly termed "engineers", either as to their nativity, education, as to the cost to the state of their training, of the conditions of employment, the earnings at various life periods and other facts upon which to base conclusions as to whether the majority of these engineers are wage earners or whether they be classed as professional men. In short, we have not as yet obtained the fundamental facts upon which to consider this most important of all questions, namely, the ability of an engineer to keep and secure a livelihood and to utilize his abilities for the good of the community.

Next in importance both to the individual engineer and to the public is the necessity of diffusing correct information as to what the engineers have done and can do. On all sides the opportunities for greater health, comfort and prosperity are being neglected simply because the public as a whole does not know what can be achieved. Sewers, drains, highways, waterpower, irrigation systems and innumerable other works of greater or

less magnitude are neglected or the construction put off on account of general ignorance concerning cost and benefits.

The third great question is that of taking a proper part in the political activities of city, state and nation. In the past many engineers have rather prided themselves on keeping out of these affairs. The engineering profession is practically unrepresented in Congress, in state legislatures, and in municipal bodies. It is true that the engineer is one of the most valued of the hired men but he is rarely placed in a position where he can exercise executive discretion in any public office.

Summing up these comments on Dr. Hollis' paper the point to be emphasized is that we should not view with alarm these manifestations of restlessness in forming new organizations but should aid and encourage every activity which leads to discussion and to a better understanding of the present situation. The Engineering Council can do its part, the annual Conference on Co-operation can bring together some other agencies, the American Association of Engineers in its all-embracing human problem can turn to useful ends the activities of the younger men, the proposed Academy of Engineers can awaken interest among the older men. All of these help in arousing individuals and organizations to greater interest in fundamental problems. All of these efforts taken together fall far short of utilizing the complete power of the 100,000 or more engineers scattered throughout the country. Organization and reorganization, discussion and co-operation are all evidences of life and progress. We are still far from realizing our ideals and we cannot approximate to them until many experiments have been tried and by a process of elimination the less valuable societies have dropped out of view.

Let every engineer as an individual and as a member of society continually ask himself as to whether he is doing his best and whether the organization to which he belongs is effectively occupying the field. Let him compare as far as lies within his power the activities and results of his local engineering society with those of the Cleveland Engineering Society. Let him take part in a comparison of methods such as is possible at the annual conferences on Co-operation among engineering societies. When he has exhausted his local resources, when he has seen to it that his state society is doing its part, particularly in state legislation, then let him enter the national or specialized organization, whether electrical, mechanical, or mining, urging it up to its highest degree of efficiency not merely in technical lines but more than this in the greatest of all problems, that of service to the individual members and through them to the public.

F. D. Richards.—Dr. Hollis has presented to us in a very engaging way a subject of vital importance to the profession.

It cannot be disputed that today engineers are not credited with that prominent station in the community that their work entitles them to. Their mistakes are apparent to the public and duly criticised, but their successful combat with almost insuperable difficulties are passed by unnoticed. The public class us as high grade mechanics, and many manufacturers consider their engineers as non-producers and in no way contributing to the success of the business. Engineers are considered expensive luxuries, and not the economic necessities they really are, and it is entirely overlooked that to them is due in a large measure the credit for the high state of economic production as it obtains today.

Business men assume that engineers do not have business sagacity, and, at meetings of government boards operating large manufacturing enterprises their attorney is almost always pres-

ent, while their engineer is frequently absent. This attitude tacitly assumes a business acumen of a high order on the part of the attorney and that the engineer is concerned only with a bottle of drawing ink or a reagent.

Seldom do we find an engineer included in a commission created to handle a civic undertaking, but we do find that it is the exception when the legal profession is not represented notwithstanding that such undertakings may be almost wholly of an engineering nature.

The public assumes a similar attitude toward engineering. We have seen in the press sarcastic criticism of "exorbitant" fees of $100.00 per day paid for expert engineering services, but can anyone recall a single instance where any such comment was made concerning fees running into the thousands of dollars to lawyers and physicians?

Undoubtedly, engineers, the term "engineers" to include all those having to do with applied science, should take a vigorously active part in civic affairs, to the end that the public may know that many civic problems may best be handled by those skilled in engineering. It is only human nature for those who successfully seek public office to reward those who assist them to such end, and if engineers desire such recognition they must enter the political arena.

How best to remedy these conditions is a problem not yet solved. Publicity is being tried; co-operation, advocated. Dr. Hollis has suggested several methods for bringing about the desired result, and it is to be hoped that engineers will try out one of them. Here and there throughout the country enthusiastic, earnest men like Dr. Hollis are doing their "bit", but for success they must have the hearty co-operation of every member of the profession. We should be the actors, not the audience.

A. J. Himes.—Dr. Hollis has come to us to urge co-operation. Does co-operation mean my way or yours? Is it give or take, or both? What has he to give? He did not say. He would have us fall in behind the leadership of the national societies and swell their numbers, their income, and their power. For what? We have a problem of the first order. Let's solve it like men, like engineers.

The time is at hand when collective efforts are in vogue. Individualism has been relegated to the past. Progress in human affairs, growth, advance and victory can be achieved only by united action. This has been foreseen some years but the profession is conservative and disposed to follow. Labor leaders have seen it. Witness their power. Farmers have seen it. The organization of the Grange has been of untold advantage in the protection of their interests. Architects, teachers, doctors, lawyers, bankers, salesmen, all have felt the need of co-operation but the engineers.

As a profession engineering is not homogeneous. It is ill defined. The A. S. M. E. is dominated by manufacturers and salesmen. The A. S. C. E. includes men engaged in large financial and commercial enterprises, contractors and promoters. The interests of these men are not the interests of the draftsman, the transitman, inspector and ambitious young men from whom the membership of the societies must be recruited.

Collective endeavor implies a common interest and to permit the discussion to go forward it is here assumed that a professional man is one who engages in his life work because of an overpowering desire to achieve some beneficent and important result through the application of scientific knowledge. Without that purpose, great men have said no man can do his best. Its possession is the "open sesame" to professional life.

Professional men, as thus defined, have always inclined in their social affairs to a discussion of professional studies because those things were next to their hearts and gave them pleasure. Today it is not because their

hearts have failed but because their stomachs rebel that they are impelled to think of things material and let's add financial and political. Conservatism protests but the children must be fed. It is hunger of mind and hunger of soul that leads young men of superior attainments but of little business experience to demand a chance to be heard in the councils of their rulers.

We have urged young men to study with promises of adequate reward. After four years of hard work and self-denial the investment of three thousand dollars and four years' time, the leaders of the profession permit them to earn laborers' wages and felicitate themselves upon their shrewdness.

Business men are learning that square dealing with the public is the road to success. The age of free competition is passing. Standards for compensation other than unrestrained selfishness are the order of the day. The plea for better working conditions for the would-be engineer is in no sense a plea for either charity or justice. It is a suggestion for the conservation of one of the most potent resources of the nation. Only the blind can fail to see that the strength of our country lies in the ability of her sons to apply scientific knowledge. If all citizens could explain the baking of bread or the use of a compass, the country would not be poorer. If by using his brains one man does the work of two he should not be limited in pay because the intentness of his application has left no time or skill to dicker. It is worth while to encourage the student, to be fair with the young engineer, and stimulate the development of the greatest possible number of men skilled in the application of science to the end that the country may be made richer and stronger and withall a better home for her people.

We ask for an organization of the engineering profession that will serve its material interests; a democratic organization that will be both efficient and free from favoritism. In this organization we believe the local association should be the unit and that all semblance of paternalism or autocracy be avoided with the utmost care.

We see nothing democratic in the Academy of Engineers. Experience affords no data from which to project a curve showing the democratic tendencies of the national societies.

We seek co-operation, and ask of both missionary and emissary: what have you to give?

R. W. Adams (President, Providence Engineering Society).—Dr. Hollis hits the nail on the head when he states that "A member gets out of an association what he puts into it and more". This being true, the corollary is also true, and it might be stated in general that if a member has no opportunity to put his time and effort into an association, he gets little out of it. This I believe is the sum of the situation with reference to the national engineering societies and is probably in the main responsible for any feeling that there may be that it does not pay to belong to one of these societies. Such a feeling is, however, short-sighted and there are thousands of engineers who feel that it is their duty to contribute to the support of at least one of the great national societies, knowing that the work of the society contributes tremendously to the standing of the profession in general and thus indirectly to their own welfare.

There are, on the other hand, many engineers throughout the country so constituted that they cannot be satisfied with passive membership in an organization but must have something to do, and it is to such men that the section or local society most appeals as offering an opportunity for the outlet of their enthusiasm and for the satisfaction of the social craving which is present although sometimes latent in the make-up of every engineer.

This is the reason for the growing success of the local engineering society, and the wise policy on the part of those in national authority will be to take this important factor into the fullest consideration. Only thus can they succeed in mapping out an organization which shall be suited to the needs and capable in enlisting the common support of every engineer in the country in the tremendous work that is ahead of us during the war and in the wonderful period of reconstruction which is bound to follow.

I am glad to note the stand which Dr. Hollis takes in emphasizing the importance of engineers without regard to specialties or affiliations coming together for acquaintance and for common action as citizens, particularly as this was recognized two years ago by those who reorganized the Providence Engineering Society on its present basis which includes engineers from all branches of the profession.

I hope that Dr. Hollis will take this as a message from the Providence Engineering Society together with our commendation of the broad-minded attitude which he assumes in the paper under discussion, and our best wishes for the complete success of his far-sighted plans.

C. E. Drayer.—In the few years that engineers have been working towards closer organization, some fundamental facts have been discovered. It can now be said without contradiction that on the proper development of the local society will rest the future strength of the profession. Despite the offer of this foundation stone by the Conference on Co-operation for the structure of state engineering organization, it has been pushed aside by the creators of the Engineering Council. Let them be not surprised when a better builder takes the rejected stone and sets it up as the cornerstone.

It might be well at this time to reread the first three resolutions adopted by the Conference.

1. NATIONAL SOCIETIES. As a preliminary to all efforts toward co-operation among existing engineering organizations there should be the expressed intent to assist in the advancement of engineering knowledge and practice and the maintenance of high professional standards.

2. LOCAL ORGANIZATIONS. The invigorating of local societies is fundamental because of the fact that while the great National Societies are important in setting standards and in considering broad problems, yet local affairs make up at least nine-tenths of the vital problems of the engineer's life. In each locality where there may be a dozen or more engineers so situated as to be able to meet occasionally, there should be formed, if not already existing, an engineering association embracing all professional engineers and others interested in engineering to discuss and act upon these vital problems.

3. HOME RULE. Each local Engineering Society should be autonomous or self-governed, wholly free in its activities from any dictation or control by other association or connections, fully adapted to local needs and conditions, and exemplifying in its activities the principle of complete home rule.

And further

(C) Be it resolved, That this Conference requests and urges the national engineering societies in designating the Engineering Council to give consideration to and create, as soon as proper deliberation may permit, the machinery necessary to provide for a general permanent body made up of representatives of the various national, state and local engineering organizations of the country, in the interest of the common welfare and advancement of the profession as a whole.

What's it all about? Do the cre-

ators of the Council think that the societies whose delegates adopted these resolutions are going to be satisfied with the Council as now constituted or with what it is doing? Much talk is a necessary preliminary to big action. But the talking stage has now reached a staccato demand for action. A careful study of Dr. Hollis' address leads to approval of all he has said and an appreciation of what he is trying to do. The inference is that he lacks support in the Council in carrying out his plans.

Provision must be made for putting into practice that form of co-operation which will bring to organized engineering the same success that has come to other co-ordinated effort, such as is being secured by the United States Chamber of Commerce and the American Institute of Architects. We must continue to carry on our altruistic endeavor as in the past, but we must also care for the material and selfish interests of the individual member of the profession in the bread and butter line. Society today moves by organized classes. Engineers can hope to play their full part in modern society only when fully organized to act as a unit, be it local, in town or county, or in the state or in the nation. The suggestion contained in a question in the discussion on page 586 of the October, 1917, proceedings of the American Society of Civil Engineers merits consideration. "As a further suggestion to constructive work, would it not be feasible to require as a prerequisite to admission to one of the national segregated societies that the candidate should hold membership in the appropriate local society?"

A development of this principle would lead men naturally to the National Societies through the local society. It would also strengthen the local society and help to bring into organized engineering the many thousands who are now without organization affiliation.

W. H. Hoyt (Duluth, Missabe & Northern Railway Co., Duluth, Minn.): I have always been in favor of something in the way of an organization that might unite all the men in engineering activities throughout the land, with a view to giving the profession a better standing and opportunity for more aggressive and concentrated work. This has been the aim of the meetings which have been held by the Committee on Engineering Co-operation.

At the last meeting of this committee in Chicago, it was practically decided that nothing definite would be carried out until the organized efforts of the four societies were put into actual operation and they were given an opportunity to demonstrate what could be done. This has resulted in the Engineering Council. Up to the present time, I have no knowledge of any definite progressive action taken by the Council, but it is undoubtedly working on the problem and will be able to accomplish something definite in the near future.

It seems to me that if the engineering profession is to be united in some organization that will be controlled for the benefit of its members and by the best element in the profession, some aggressive action must be taken by the officers of the different leading societies.

Wm. M. Kingsbury (Secretary, Ohio Chapter of American Society of Heating and Ventilating Engineers): It seems to me that co-operation should be attempted in some form and revisions and changes made from time to time so as to build up a successful society along the lines proposed by Dr. Hollis.

I have had in the past ten years some experience in the American Society of Heating and Ventilating Engineers, having served on its Board of Directors. We brought about the same results as desired

by Dr. Hollis and have been very successful, having today about 800 members. We found it necessary to try out several methods and finally settled upon (3) and (4) cited in the paper; (3) by means of the Council starting with a few societies which adopted the constitution and by-laws of the parent society and over which it retained control; (4) by organizing in every state a chapter composed of smaller groups in the cities. Eligibility to membership in any local or state chapter is predicated on membership in the parent body. Our by-laws and constitution are quite simple and a copy can be readily obtained.

The hope expressed by Dr. Hollis "that all engineering societies will take a hand as societies in everything that is good for the county" is quite a dangerous proceeding if carried to a point where individual thought and opinion is suppressed or if we venture commands or take action on questions of public interest in which we are not well versed.

C. Francis Harding (Head, School of Electrical Engineering, Purdue University).—It is difficult to realize, when viewing the present war from a broad viewpoint, why such a calamity should have been inevitable in order "to make the world safe for democracy". Whatever answer to that question may ultimately be found, however, the engineer and engineering will have benefited quite as much, if not more than any other profession, from the awful struggle which is now raging. The engineer is now being forced into the public eye in spite of himself, and both the art and science of engineering are being voluntarily recognized in their true perspective in society as a result of the demands of modern warfare.

While this condition exists for the individual engineer and his profession, however, and although new verile engineering organizations of rapid growth and up-to-the-minute policies are making meritorious history and serving the needs of the young and more or less isolated engineer, the inertia of conservatism, precedent and local autocracy are hanging as a mill-stone about the neck of some of the national engineering societies.

Co-operation among engineers, to even a greater extent than among loyal citizens not blessed with such special equipment, is of paramount importance in this struggle. However, this hearty and enthusiastic co-operation does not make itself felt as a vital force in the local branches and sections of the national engineering societies. Groups of able engineers banded together in different parts of the country in sections of national societies, do not have the recognition or influence that they should among the committees and governing boards which are in a position to exert a tremendous influence for the public weal at this psychological moment.

The writer has recently been publicly criticised for accepting membership in one of the prominent national societies because of its autocratic methods. However, this particular organization, with its officials elected from all sections of the country and its committees bringing together in New York and elsewhere enthusiastic members of widely varying ideas and constituencies, is by far the most democratic of the national societies in its representation.

Speaking from an intimate knowledge and considerable experience with two such societies, which are considered, however, to be representative of many, the writer finds but very limited representation of geographical sections once a year before the parent body. The branches of one such organization have recently been granted permission, upon their urgent request, to be heard once a year, provided the expense of such representation is

borne locally. Such expense, if incurred at all, would necessarily have to be shouldered by the lowest grade of membership, which naturally is least able to bear it. Yet from such a source most of the new membership, representing the future potential energy of the society, is now being enthusiastically recruited. Although the government is selecting such members to fill positions of trust and officers' commissions in this crisis, the deliverations of such engineers are accorded an ever decreasing recognition in the proceedings of the society. Realizing full well the disastrous effects upon the future of engineering and humanity at large of curbing or disheartening the young engineer in his ambition to invent, imagine, create, construct and broaden his horizon, especially during this period when such development is sorely needed, the following comparative purposes of a new progressive organization and an older and more conservative national engineering society offer a striking contrast worthy of careful analysis.

I—"OUR OBJECTS"

To raise the standards of ethics of the engineering profession, and to promote the economic and social welfare of engineers, especially by:

Affording means for the interchange of information beneficial to members of the engineering profession;

Maintaining a service clearing house for the benefit of members;

Supervising proposed legislation affecting the engineering profession and taking any action necessary or advisable to safeguard the profession's welfare;

Promulgating the association's ideas through proper publicity, and fostering a brotherly spirit among engineers.

II. "The objects....are the advancement of the theory and practice of....engineering and of the allied arts and sciences, and the maintenance of a high professional standing among its members."

The necessity of maintaining an unquestionable prestige and high professional standing on the part of at least one national society in each branch of the profession is freely granted. Is this requirement incompatible, however, with a more democratic organization or a broader policy of assistance and training of the younger engineers than exists at present?

The Engineering Council may be able to assist materially in this matter if it will, but if its purpose is rightly understood, it tends to weld together like organizations rather than provide for the necessary broadening and democratization of each society within itself.

B. A. STOWE.—Engineering and Co-operation, as presented in Dr. Hollis' admirable paper, suggests in the mind of the writer a line of thought that three years back would have been held wholly untenable or, if not, to be impossible of materialization. Indeed, at the beginning of this world war, who would have predicted the possibility of organizing and putting into operation such stupendous forces of relief and succor; such correlation of heretofore unrelated factors, each characterized by traditional prejudices inborn, as it were, and selfish in the extreme.

Today a common interest unites a world movement toward democracy, and we are amazed at the unanimity of purpose and the spirit of co-operation that is everywhere manifest and which alone can accomplish the desired end. And it is all in the cause of democracy. This principle is the basis of all good government. It is the basis of all good society. "A government of the people, for the people and by the people." A society of which all are a part.

Co-operation is, then, the very foundation of democracy, and world democracy must mean world co-

operation. Now the co-operation that is so manifest and which has enlisted your efforts and mine to a degree never before realized, is what is going to win this war. It is setting to work such tremendous forces that we wonder whether we will ever be able to restore commercial equilibrium. And yet we know that "action and reaction are equal and in opposite directions". Destructive and constructive forces are opposed and while the powers of destruction seem now to be the dominating influence, we know that there must come a reaction, characterized as constructive good, and the greater the forces operating to destroy, the greater must be the efforts for restoration.

So if we agree that co-operation has made possible the organization of resources for carrying on a world war, we should agree that co-operation is desirable, effective and necessary to establish peace or equilibrium.

If, as Dr. Hollis says, "this is an engineer's war", then should it not be an engineer's peace following? If our engineers have co-operated to produce a "Liberty Motor" for war, they can and should co-operate to produce a "Liberty Motor" for peace, and must if commercial supremacy is to follow. The "Liberty Motor" symbolizes the spirit of co-operation; not only its design, but the factors involved in production, and these factors include all branches of engineering. Then haven't we set on foot an ENGINEERING DEMOCRACY, if you please, and destined to become the real "CONQUERORS" for peace and the pursuit of happiness?

Said President Wilson at a recent meeting at Buffalo: "We are all of the same clay and spirit, and we can get together if we desire to get together. Therefore, my counsel to you is this: let us show ourselves Americans by showing that we do not want to go off in separate camps or groups by ourselves, but that we want to co-operate with all other classes and all other groups in a common enterprise, which is to release the spirits of the world from bondage."

"I would be willing to set that up as the final test of an American. That is the meaning of democracy."

Segregation of engineers or of societies or groups of engineers cannot win the war nor can it promote peace. An Engineering Confederation is the logical exponent of engineering democracy, and it should be and can be national in scope.

If this be granted, we have simply to consider the United States Department of Agriculture and the economic value of its various activities and we have a reason if not a plan for the establishment of a Governmental Department of Engineering. Such a department, with a secretary sitting in the councils of the president as a cabinet officer and in executive control of all activities of an engineering nature in national enterprises would be a most effective stimulus to the engineering profession although a long-deferred recognition of the value of engineering to the needs of the nation.

Present bureaus of a technical nature and allied with engineering, as well as the much abused Patent Office Department, could be transferred from the Department of the Interior and given a new impetus, making them more than a mere tool incidental to the promotion of the "Useful Arts" by giving them direct initiative for the public good.

A united effort of all engineers directed to the establishment of such a governmental department would, in my opinion, secure a just and proper recognition of our profession and prepare the way for an effective co-operation between the various engineering bodies and with the nation at large. Thus having secured a definite focus or head, represented by "Uncle Sam", we can effectively

unite our forces in one great Engineering Democracy.

DR. IRA N. HOLLIS.—I have read with interest the discussion of my paper on "Engineering and Co-operation", and I find myself so fully in agreement with everything that all of the writers have to say that I should not be able to add anything illuminating except by going into lengthy details.

We use the word "co-operation" very loosely and we talk a great deal about it, all of us hoping, however, that some way will be devised by which engineers can come together in a better way. As a matter of fact, all engineers agree as to the end to be secured. The only disagreement that I have ever discovered either in the national societies or in local societies lies in the question of method. I know the weakness of national organizations, and I fully believe that the great national societies will be the better for an intimate relation with the local societies all over the country. I have a hope that the Engineering Council will become a representative organization, accepting all national, state and local societies. That is a matter for time and I do not believe that the formation of new societies to bring about co-operation is as fruitful as the re-formation of the older societies into active agencies for the whole engineering profession.

One of the curious phenomena that has seemed to me very widespread in the United States is the vague belief on the part of many engineers who live far away from New York that in some way they have no voice in their society's affairs. As a matter of fact, every man has pretty nearly as much voice as he desires if he really makes an effort to express his desires. Having been president of one of the large national societies for one year, I have been strongly convinced that the local societies will be heard if they make an effort. In the Mechanical Engineers, the sections have been encouraged by the national organization and we who have been serving on the Council of the Society hope that more sections will be formed. What we find in our societies, however, is common to our federal government, common to democracy in this vast extent of territory that the United States occupies today. A state is heard exactly in proportion to the value of what it has to say. A local section of our Society is in the same relation to the national society. Every individual and every local section gets out of the society exactly what he puts into it. I cannot help but believe, therefore, that it is vastly better for us to work together in the great national societies to promote the welfare of engineering and to afford the local section ample opportunity to express itself and to encourage the formation of local organizations of engineers with regard to the specialties that they cover.

One or two speakers have seemed to imply that the Engineering Council was formed as an answer to two or three other organizations recently formed. As a matter of fact, that is not the case. The Engineering Council was formed to enable four societies to work together on national questions, especially at this important time. Its promoters hope also to be able to make it the machinery for bringing all engineering societies together. With time, that is certain to come about, because it is in the air. New societies may hasten this movement and this short statement that I am submitting is with no thought of discouraging any society from going ahead in its activity. It is an expression of belief that only through the national societies already existent and through their co-operation with the local societies, whether these societies be sections or not, can the engineers come together in a larger way.

German vs. American Manufacturers

HERBERT H. DOW*

Paper Presented October 16, 1917

Index No. 658

Mr. Chairman, and Gentlemen: I think all young men, when they decide to take the chemistry course in any college or university, have more or less doubt in their own minds as to whether they will be able to compete with the German chemists who come over here in large numbers and are willing to do chemical work for very little money. They begin to wonder if they have the ability of the German chemist, if their brain is equal to that of the German, if the accumulation of knowledge that exists in Germany will not be too great a handicap to the American that he will not be able to successfully compete as an ordinary analyst of chemicals.

I think most young men, when they take the chemistry course, have an ambition to earn a hundred or one hundred and twenty-five dollars a month as an analytical chemist. Of course, that was in years gone by when the recent salaries were not heard of. After he begins to compare and wonder whether these facts are going to be a handicap, he then goes one step further, and wonders if the tariff laws or the trust laws, or some of the legislation that is so effective in Germany will not be the means of preventing him from earning as good a living as he otherwise would.

The subject as it appears to the young chemist under those three headings, I think, would be as good a way as any for us to take it up this evening, so I will start by trying to compare the German brain with the American brain. I realize that is a ridiculous thing to do, and almost any comparison you make is a good deal like the vaudeville artist who tries to prove something and makes a joke out of it. But we do have a few things from which we can gather a little information on this subject.

For example, the Germans have built manufacturing plants in the United States, and Americans have built manufacturing plants in Germany—I think more particularly in other countries rather than Germany, but I think the Westinghouse Company has one or more plants in Germany. They have very successful manufacturing plants here, but their German plants were not particularly successful, so I have been informed by a former official of the company.

The Siemen-Halske Company, about twenty years ago, came over to the United States and started to make the Siemen-Halske generator. I think many of you remember that type of generator. It had an armature outside of the field coils, and the commutator was on the outside of the armature, and it was quite a novelty, possibly you might say a monstrosity. But the great reputation the Germans had for work, that is, scientific work, and their great knowledge of electrical matters, was such, or at least in the opinion of a great many Americans their knowledge, or what they supposed to be superior knowledge, was such that they found a ready market for those generators. About the time those generators came out, the Westinghouse came out with a generator with multiple poles, very similar to the type they use today with the exception that there were no commutating poles on it. We have two of these machines at the present time in Midland. One of them we bought in 1897, a large, good machine. It is practically as good as new at the present time. It does not commutate quite so well under a change of load; but for all practical purposes

*The Dow Chemical Co., Midland, Mich.

it is a good machine. At that time the Siemens-Halske machines were being sold quite largely; I doubt if anybody in this audience has seen a Siemens-Halske machine in operation in ten years. But I know of no case where America has been able to go over to Germany and manufacture unless it is possibly the Westinghouse air brake, and there are several reasons why that was a success. Neither do I know of any particular case where the Germans have come over to America and made a very signal success as manufacturers. I think it was the Dykerhoff Portland Cement Company that built a plant over here, which was a model plant in a way but it is not a brand that you hear of frequently at the present time.

As far as the remarks I have made so far are concerned, it does not seem to indicate anything as comparing the German brain and the American brain. I think, however, in the matter of advertising the German has us beat a mile. We will take for example a chemcial compound such as aspirin or phenacetin. There are a number of others that do not occur to me. Those compounds are all well known. Doctors in America recommend them, and they are in a different class from a good many compounds that are brought out and sold in America, for example, bromo selzer. While it is a very successful medicine, at least we think it is, and aspirin is also a very successful one, the doctors in America will recommend one and condemn the other. And my personal opinion is that it is a matter of advertising. The Park-Davis Company has a compound called Takadiastase and they have a number of other similar compounds on a par with aspirin and that class of compounds, but I think most of you gentlemen here are far more familiar with the German names than you are with the American names, and I am sure the physicians are. However, I do not think that is as good an illustration as we can get.

Everybody knows that potash is a great fertilizer, at least they think they do. The United States is doing more experimental station work than any other nation on the face of the earth today. When I say today, I do not mean conditions since the war started, I mean under normal circumstances the United States and Great Britain are the two leading countries in agricultural experimental station work. The first great station was at Rothamsted, in England, and that has been the model from which other stations have started and developed. Possibly the Geneva experiment station in New York state is one of the most important and one of the most exact of any of these experiment stations; and the Geneva experiment station for three consecutive years tried out potash experiments in every potato district on Long Island. In not one of those experiments did they find a single case where the expenditure of money for more than one per cent of potash in a fertilizer was justified, and in nine cases of of ten it did not pay to buy the potash at all; and yet those potato growers on Long Island are putting more and more potash into their fertilizer, thinking each year they must use more than they did the year before, until they have got up to about eleven per cent of potash.

Last spring I was crossing the Chesapeake Bay, and got acquainted with a man who is a potato grower on that strip of sandy soil between Chesapeake Bay and the Atlantic Ocean. He told me when they found they could not get any potash the year before he thought he would quit raising potatoes, and early potatoes are the principal product raised in his neighborhood. All the farmers around there, he said, were very doubtful as to whether it would pay them to put the seed in at all. They had always used fertilizer, and they had always used a large amount of potash in the fertilizer. He said, finally some of them put in some potatoes and they got

the largest crop they had ever had. When fall came they had their Potato Growers' convention, and the sensation of the meeting was the fact that they all had a big crop of potatoes without the use of potash. The biggest potato grower in that community got up before them and gave them all the laugh. He said, "I have not used a pound of potash in five years." My potato-growing friend said, "You could not sell a pound of potash down in our territory on a bet." They were going to establish a new experimental station some years ago, and a man was sent to show them how to lay out their experimental plots and to do the work. It was no secret that this man was in the employ of the Kali-Syndicate or German potash monopoly, and he laid out two plots to show whether muriate of potash was superior to sulphate of potash. There was no plot laid out to see whether potash was needed on that soil. That was taken for granted; that was an axiom. Everybody knew, of course, that potash had to be used. By some mistake or oversight another plot got in there that did not have any potash in it, and at the end of the year, the first year of this new experiment station, they advertised broadcast their report, and said, "unfortunately there was some mistake made, because our plot that had no potash on it did better that the plots that had either sulphate or muriate." They never for a minute questioned the fact that they were mistaken.

I have a hobby of agriculture and horticulture, the growing of fruit, etc., and I have written four or five articles for the *Rural New Yorker*. Every one of my articles was accepted but one, and that one related to an experiment in which I had used some potash, and it had given no favorable result. They returned the article to me and said that isolated experiments could not be depended on.

I will give you one other experiment, and this is the most rigorous of all. A number of years ago, the Geneva experiment station wanted to know the effect of potash on apple trees. They bought a great number of apple trees of one particular variety of a very old grower, and they were supposed to be exactly alike. They grew them for one year. You will be interested in this, because it is an instance of scientific accuracy as applied to horticulture, possibly something in which you have never had the experience that you have in the scientific accuracy as applied to measurements or things that are done in the physical laboratory. As I said, they bought a great number of these trees from one grower that were said to be exactly alike. They grew them for one year, and then discarded all the trees that appeared to be more thrifty or less thrifty than the average tree. They then grafted them all over to one variety, I think it was the Ben Davis apple, or the Rome Beauty; they secured scions from one limb on a tree that they knew to bear uniform apples all over that limb. In fact, it is very rarely that a tree is not uniform throughout, unless it has been grafted. They took those scions all alike and with them grafted all those trees, grew them for a year, and then again discarded any trees that were any more or less thrifty than the average. Then they planted those trees out in their experimental plots, using not one tree to the plot, but five, and the more important plots were in duplicates some distance away from each other. Between each plot there was a row of trees that were not included in the test for fear that the roots might run from one plot to the adjoining one. That is, the trees were set out in ordinary orchard form, but between each plot of five and the adjoining plot of five there was a row of trees that was not included in the experiment. These experiments were for the purpose of testing not only potash, but phosphate, nitrogen and combinations of the three. After this orchard had been running for several years, they came to the

conclusion that the phosphate plot was doing the best. Two years later they came to the conclusion that the potash plot was doing the best, and the next year they were a little undecided whether it was the nitrogen or one of the other plots that was doing the best. The following year they had pretty good evidence that the blank plots on which nothing was done were doing the best, and at the end of thirteen years they averaged so nearly alike that a slight change on one tree would have offset any change that existed between one tree and another. The experiment has now been running twenty years, and they find the nitrogen plots are producing about the same apples as the phosphate and potash plots and the mixtures of the two. I know Professor Hedrick, who has charge of this experiment. He has been a guest at my home on more than one occasion; and I know Dr. Jordon, the head of the station. I know Professor Parrott, the entomologist, and I am thoroughly satisfied that every one of those men think that the use of potash in at least ninety cases out of a hundred where it has been used heretofore is not justified.

Now, we must give the Germans the credit for being the greatest advertisers in the world to get everybody everwhere to using potash to the extent they have, and right in face of the most strenuous campaigns by the experiment stations to head it off.

The Illinois experiment station has a man at the head of it who fears nobody. He is up fighting potash morning, noon and night, and they call him a crank. The Geneva experiment station realizes that they get their money out of public opinion and politics, and in a very diplomatic way they have been fighting it for all they are worth, but not quite as much as Professor Hopkins of Illinois.

I want to bring out one or two more points on advertising ability. I was the guest of a chemical manufacturer in Darmstadt in Germany, and he took me through a furniture factory. I might state that Darmstadt is a very artistic locality. At the luncheon they gave us, some very complimentary things were said to their guests, and I in return spoke of the thing that impressed me most, which was the art in connection with their entire establishment, particularly the artistic entrance. They replied that a man who was not artistic in Darmstadt was ostracized from society, that the grand duke of that locality was an artist, and that anybody who had any aspirations whatever to be in the aristocratic circle in any way or to be in society must display in the same way artistic ability. He said, in the same way that we have to be artistic here in order to have a stand-in in society, it is just comparable with the situation down in Berlin where anybody in order to have any standing in society or in the community has to be a military man, because their grand duke down there is a soldier. He said, "I refer to the Kaiser."

He took me to the sales department of this furniture factory—the sales rooms. They had many rooms about the size of rooms in residences, and every room was fitted out the way it would be in a residence. The salesman who conducted us around preluded his remarks about the furniture in each one of these rooms by a remark something like this: "This furniture in here is by," and then give the name of the designer. He would say, "He is a very famous artist," and then go on and talk for five or ten minutes upon the great ability of the particular artist who was the designer of that particular piece of furniture. We had all kinds of admiration for it because we knew that very great artist would have done nothing else than produce something that was very artistic. If we failed to comprehend the great beauty of it, we knew it was our own inability to comprehend these very fine artistic features that must have existed in that particular piece of furniture. Naturally that is an effective

way of selling furniture to Americans, and every piece there was by some famous artist. They ranged in price from, for an ordinary bedroom set—I should not say ordinary, because they were by these great artists—but they ranged in price from, say, six hundred marks for a bedstead, to twelve or fifteen hundred marks for a bedstead or possibly two single bedsteads and the ordinary furniture that goes with it.

I might make one or two more remarks in regard to comparing the German brain with the American brain. In our chemical plant in Midland we have a number of men who are evidently of German descent. We have a number of others who are evidently of descent of other countries rather than Germany, and there is no possible way of comparing them that I know of. Some of these men display very great ability in one line, and others in others, so far as I am able to judge. That has been a question that has bothered me for a great many years, because I was afraid we were going to get licked by the Germans and I wanted to know really whether these Germans which we had in our employ were very much superior to those who were not Germans. As far as I am able to distinguish, there are great men both in Germany and in other countries.

The remark recently made by the former comptroller of currency of the city of New York, who has also been the agent for a big German dye syndicate, that if all the Germans in America were prevented from taking part in industries in the country, every dye plant in the country would shut down, is not correct. It does not apply to our plant. Germany is undoubtedly excelling in advertising its educational abilities, and a doctor can always have a little better standing in his community if he has spent some time in Germany. I do not mean to say that he has not gained a decided and distinctive advantage by that visit in Germany, but I very much doubt whether his advantage was greater than the German would have obtained by spending an equal amount of time in the United States. But there is one thing about it, and that is that a great doctor, in nine cases out of ten is a pretty efficient advertiser. He does advertise according to the ethics of the medical profession, but the doctor who can get himself before the public and be thought a great doctor is, to a certain extent, a great doctor. If he has other things equal, he is a greater doctor than the doctor who is not known to the public. He has greater opportunities for practicing the fine points in his own profession, and has the chance to become a greater doctor. Possibly that is one of the reasons doctors go to Germany and advertise the great ability of German universities. I think that not only applies to doctors but also to college professors. They come back to America and are more capable men because they have seen things in a larger part of the world. It is therefore to their advantage not to run down the place where they got the latter part of their education.

A very good illustration of the fact that this supposed German superiority has been very well advertised in this country was a speech made before the bankers in New York recently. One of the prominent bankers stated to the members of the convention that in Germany there was a plant that employed 175 chemists and spent $75,000.00 annually in original research work. He said, "Until America reaches the point where they are willing to spend $75,000.00 a year on original research work, we are bound to be beaten, and we cannot hope to succeed." The banker had been well informed about German research work but knew nothing of research in his own country, because the latter had not been advertised.

Some years ago I went through the research department of the DuPont Powder Company. It was a plant devoted entirely to research work. I

am morally certain that many times $75,000.00 per year were being expended in that plant alone. I explained a few days later to the head of the research department of the General Electric Company, what I had seen at Wilmington, Del., and he said: "We are spending a very large amount of money." I do not remember the amount. I know also that the Eastman Kodak Company is in the same class. The people in America have not had this advertised to them to such an extent, so that they believe that this great expenditure for research work is a thing that is done in Germany only.

I had a talk two weeks ago, I think it was, with Doctor Baekeland, the inventor of the Velox photographic paper, and also the inventor of Bakelite that is used for making the records for talking machines. Doctor Baekeland, by the way, is a Belgian who was educated in Belgium and Germany, who talks German very fluently, and who is very familiar with conditions in Germany. He said: "The thing I know the most about is this photographic business. They tried to make a film in Germany, but failed." I had already understood from the Eastman Kodak Company that 95 per cent of the films used in Europe were made in Rochester; and he confirmed the fact that they had never been able to make a good film in Europe. I do not refer to the development of it; I refer to the mechanical features of a film, making a plate extremely sensitive, and at the same time making it durable.

Let us go on to the second stage. I think we have said too much, perhaps, about this relative brain power, because we do not get anywhere. The second thing is knowledge of the tricks of the trade. Now, we will say right off, "Why, of course in the manufacture of chemicals they have the advantage of us, because they have all this knowledge and we do not have it. Let us see how they do it over there. They learn how to make a dye in the laboratory in glass beakers. Then there is a demand for a few pounds per year, and they make it in bigger vessels, but still make it by the laboratory method. Later a market develops for it, and instead of pounds per year, tons per year are required. But they still work by the laboratory method and have more or less of the laboratory size to their apparatus. I do not mean to say by that that they are not doing things on a big scale in Germany, because they certainly are, but it is still on the laboratory scale to some extent, as evidenced by the fact that the general manager of the biggest German dye plant a few years ago, at the time of the World's Congress of Applied Chemistry in New York, condemned everything that was being done over here, particularly the large units of apparatus being used. He said, "These sulphur burners have thirty tons per day capacity. It is ridiculous to go to such a size, because if one of them shuts down it interferes with the operation to such an extent that it is not commercially advisable. Stick to smaller units and more of them." At the very time he gave this advice not to put up a thirty-ton unit, Mr. Wedge was building a 130-ton sulphur burner, and so far as I know the sizes are still on the increase.

In the United States, manufacturing as we know it today began with the development of the steam engine and followed along for a number of years with the growth of the steam engine. In England, it was not until the time of the Civil War that we became a large and fairly prosperous country in the making of chemicals according to modern manufacturing methods as we now understand it. A heavy tariff was put on most of these manufactured articles, solely for the purpose of raising the revenue necessary during the Civil War. But that instantly stimulated manufacturing to such an extent that it became very profitable, the best brains of the

country were engaged in it, and it grew very rapidly. But a new problem arose. If a man made saddles, he would make one or two, or occasionally someone might want three or four. He would make each one different, according to the order they gave. All of a sudden there came a demand for 10,000 Springfield rifles, all of one kind, and along towards the close of the war somebody conceived the idea that if those Springfield rifles were only made so accurately that no fitting would be required in the field in case one part was broken, it would be a military advantage. And so they decided to make this rifle on the interchange plan. They had no idea that it would be cheap; they were not looking for cheapness; they said, "Out in that field in the time of battle is no time to repair a gun, and have files and tools for fitting a piece. We need them made with such accuracy that in the shortest possible time that lock or whatever part of the gun it may be, can be repaired, and we want every part of it to be interchangeable." So they began to make the Springfield rifle on the interchange plan.

This was the first time in the history of the world that anything had been made on the interchange plan. It was a new idea in manufacturing. Contrary to the predictions of everyone, they found it was cheaper to make these rifles on the interchange plan than it was to make them by the old method of less accuracy which required fitting each part independently.

Shortly after the war began, England also saw the military advantage of making guns so that all the parts were interchangeable, and a full set of machinery was made in the Connecticut valley for the manufacture of the Enfield rifle. This machinery was copied after the machinery used for the Springfield rifle, and was shipped from the city of Hartford to England, and that was the beginning of the manufacture in England on the interchange plan.

I think as engineers you all believe that the automobile as it is made today, especially the method of assembling that was introduced by the Ford plant, not only for making the different units, but for finally assembling these units and making a finished car, would be absolutely impossible if it were not for the interchange plan. And what that practically means is that the output of automobiles that you see today could not exist, there would not be enough men to make them, if it were not for that new method of manufacturing discovered in the United States at the time of the Civil War—this interchange system of making parts for mechanical things. We also, I think, realize here that there is a tremendous advantage in the accumulated tricks of the trade as evidenced by the fact that it took a long while to learn how to make a good automobile. If it took a long while to learn how to make a good automobile, it also took a long while to make any other machine. And the man who was on the job and in touch with that evolution and development was the man who knew most about it, and his competitor off somewhere else could not easily and rapidly copy and become equally good. I think as engineers you all appreciate the point.

There is a good illustration of this point. Why is it that Boston is the center of the shoe and leather industry? More particularly in recent years when you can buy machines all assembled, it is the center of the source of machines for making shoes and for all the operations in leather. In a somewhat similar way Grand Rapids is the center of the furniture industry, Cleveland and Detroit and their general locality is the center of the automobile industry. I do not believe anyone who is in touch with it thinks that the center is going to change. It is here and it is going to stay here, because we are not only learning how

to make the car itself a good car, a good automobile, but every machine that goes to manufacture the various parts of cars is being perfected, the method and system is being worked out, and men are becoming more or less proficient in operating all of these various phases of the construction in an automobile. It is going on in increasing geometrical ratio to such an extent that it becomes more and more difficult every year for a person to manufacture a good automobile other than in this very vicinity.

Prior to the war there were sixty odd thousands of registered automobiles in Germany. You know how that compares with the output of automobile factories in the United States. In Germany they do not know how to manufacture automobiles, at least on the big scale and on this interchange plan. We know that those German cars are very largely hand fitted, big, expensive cars, and as far as I know none of them have ever been built in the way that cars are built in the United States.

We say off hand that the tricks of the trade are with Germany as far as the chemical industry is concerned. The tricks of the trade I think we are all satisfied are with the United States as far as the handling of material is concerned.

Now, let us take a typical example of the manufacture of a chemical—we will say pig iron, or sulphuric acid, if you please. A man wants to make pig iron cheaper. How does he do it? He puts in a Hulett unloader; he puts in a new type of boat; he puts in a more efficient air compressor; every step of it is mechanical; not one part of it is chemical. Chemistry does not change, it stays, but the machinery wears out, and it calls for mechanical genius to keep that machinery from wearing out, to give it its maximum efficiency, to make it have its maximum efficiency to begin with and to maintain it.

Take a sulphuric acid plant, for example. How would he decrease his cost? Probably by putting in a locomotive crane for handling pyrites rather than what he had before if it was less efficient, putting in heavier locomotives and hopper cars, and putting in the sulphur burner I referred to a while ago, and so on with everything along down the line. His method of making sulphuric acid cheaper would be a mechanical and not a chemical one.

Let us take soda ash. It is used in the manufacture of soap and glass. We all know that the Solvay Process Company at Syracuse and Delray, and the other American companies, at Barberton and Painesville, and Detroit, are all highly efficient manufacturers of soda ash. It is a fact that soda ash and caustic soda sold for less money in the United States before the war than in Germany.

Why is this so? Germany is a great chemical country for she had the raw material, but the mechanical ability, if anything, favored us, at least the ability to handle things on a big scale. We have had more experience. Take, for example, a locomotive and a train. Everybody knows that it costs less per ton mile to transport freight in the United States than in any other part of the world, and if it costs less to do that particular kind of handling, why would it not cost less to do the other varieties of handling? It is not because we have cheaper labor. It is possibly because we have a United States in which each state is free to trade with every other, and there are so many big consumers that a man can manufacture on a big scale. He has the opportunity to learn how to make things on a big scale.

The facts are that we are in the United States able, with our accumulated knowledge, our knowledge of the tricks of the trade, if we want to put it that way, to manipulate material, to handle material, to transport material, and to do the various mechanical operations connected with material better than they

are in any other part of the world, so far as I am aware.

I think there are a great many other illustrations besides the ones to which I have referred, but these are probably sufficient.

Now, of the third subject I touched on: We will assume that brains are equal; we will assume that tricks of the trade are rather with us as compared with the tricks of the trade in Germany so far as it applies to chemicals that we are making now on account of the war, because during this interval we have learned the chemical reactions, the chemical features of this manufacturing. We may not be able now to manufacture as cheaply as we shall be later. We know we are not able. But it will not be chemical features that will make the difference, it will be mechanical. It is not going to take long, with any product we make today, until we will understand it so well that we will know practically all of the chemical phases of the subject, and it will only be the mechanical handling or the ability to make suitable apparatus from the engineering standpoint that is going to worry us from now on.

Another good example of the fact of America's ability to make a thing is illustrated by America's ability to make any metal. We lead the world in the methods of extracting gold, in the methods of extracting copper, and I think of all the metals. Now, an American goes to an American capitalist, and he says, "I have a copper mine out here," and the American capitalist and the banker have confidence to put in able men and spend a lot of money, and to build railroads, etc., in developing that copper property, because they say, "Why, copper is not found to any great extent in Germany, consequently, copper has to be secured here anyway, and so we are not going to be put out of business by the Germans. It will be perfectly feasible for us, under these circumstances, to compete with Germany." He persuades himself that it is possible for him to compete with Germany because he has the ore here, and they cannot bluff him out on the strength of the position that the manufacture of copper would not pay him, because he has the ore here and they do not have it in the same quantity over there. So that he has the confidence to go ahead and put in a plant and develop it. And we have reached a high state of perfection in the manufacture of all these different metals in the United States, at least so far as the principal ones made on a big scale are concerned.

But when it comes to the corresponding thing where Germany has the raw material as well as the United States, I think you would have difficulty in getting capital in the first place. They will say, "But you cannot compete with German brains. They control it."

I can give a good illustration of that. Our company, the one with which I am connected, had as its general manager a man who was somewhat conceited, and he thought he could compete with Germany in the manufacture of a chemical. We had a little money borrowed at that time—there is a little story on the first page of your *Bulletin* in reference to this subject. It became apparent to the persons who were lending the money to this company that there was to be competition with Germany, and our credit disappeared. "Why, no, you can't compete; impossible!" And some other people said, "But, Dow, you are a visionary. We all know you are enthusiastic, but forget it, you are too visionary." A good German friend of mine came to me and said, "Mr. Dow, I am talking for your own benefit; the German government is right back of the whole thing, the business you are proposing to compete with, and absolutely they would not permit you to sell these goods abroad. If they say they would not, they would not, and that is all there is to it. Now, if you do, in your childish way, believe you can make a chemical and

sell it abroad right in opposition to the law they have laid down, you are fooling yourself; you are only a child in the business." And I began to doubt my ability myself. But we finally did and continued to sell; and that is one reason why I am here to-night, and one reason why I want to inspire confidence in other people who are attempting at this time to manufacture goods and are afraid at the close of this war they are not going to be able to continue to manufacture them, because of German competition. I have every confidence that we will be able to continue, provided the third part of my subject is satisfactory.

That refers to laws, either favorable to the German or unfavorable to us. I am not going to weary you by talking on the tariff in the ordinary way at least, but I want to give you one illustration that is very close home.

In 1897 bleaching powder sold for $2\frac{1}{4}$ cents a pound. In that year the new tariff law put 2/10 of a cent a pound protective duty on bleaching powder. Prior to that time it was on the free list. The United Alkali Company of Great Britain, who controlled it at that time, said, "I know there is something doing about bleaching powder manufacture in America," and without knowing who was doing something over in the United States, they lowered the price to $1\frac{3}{4}$ cents a pound instead of $2\frac{1}{4}$ cents a pound, and paid 2/10 cent import duty. They knew the tariff had not been put on automatically; they knew somebody was back of it and got that tariff of 2/10 of a cent a pound put on bleaching powder, and knew they did it for a purpose, and that purpose was to manufacture bleaching powder in the United States. So they said, "If we are going to have competition, we had better cut the price." So they made it what they figured would not leave a sufficient margin for the American to manufacture, namely $1\frac{3}{4}$ cents a pound. But the American manufacturers started. They were not very successful the first year or two because they had not learned the tricks of the trade. After two or three years they began to be quite successful, and began to increase their plants rapidly. The United Alkali Company said, "We made a mistake, that price of $1\frac{3}{4}$ cents is too high; we should have put it at $1\frac{1}{4}$ cents a pound." And so they lowered the price, but still paid 2/10 of a cent a pound import duty. The consumer bought it for $1\frac{1}{4}$ cents instead of $2\frac{1}{4}$, the United States government had its 2/10 of a cent a pound, and the American manufacturer had the confidence of the banker and business men, because the banker and business men thought the American could make it within 2/10 of a cent of the price of the foreigner, and was willing to invest his money in it. The result was that the American industry grew, the consumer got it for a little over half price, and the United States government got 2/10 of a cent a pound, and nobody was worse off for it, unless it was the Alkali Company of Great Britain.

I think that is a phase of the tariff law that is not ordinarily explained. That is my own experience in our business, and I am not telling what I am getting from anywhere else.

On the subject of bromides, as referred to on the first page of your *Bulletin*. When the German began to sell bromides in the United States at a very low rate, we ceased to compete here. They paid 25 per cent ad valorem for every pound they sold in the United States, and continued for a period of 3 2/3 years to sell bromides in the United States and paid 25 per cent advalorem. I think if there had been no 25 per cent advalorem possibly the bromide business would have been wiped out of the United States, and forever after all moneyed men in the United States would have said, "It is impossible for us to compete with Germany." Yet we know that the import duty of 25 per cent advalorem those Germans paid when they sold bromide in the United States was practically the

price they received for it here. It was selling for 49 cents abroad, and they sold it here to anybody who wanted it at 15 cents a pound. After you figure the transportation, commissions and everything else, how much money did they make after paying 12½ cents a pound import duty? Was that because they could make it cheaper in Germany? No, it was because the trust laws and experience of Germany had been such that they said. We can wipe a competitor off the map and make more money by monopolizing the business, than we can by continuing to compete with them."

Now, I am not advocating the wiping of a competitor off the map, but ability to work as a unit is certainly an advantage to a German, and the laws they have in Germany that are the opposite of the Sherman law, are of great advantage if used not for illegitimate purposes or for purposes that we consider underhanded or not fair, but it would be the greatest advantage in the world for fair methods.

For example, a sewing machine sold for about $9.50 or a little more, some of them as high as $10.25, before the war. You have sewing machine manufacturers in this town. I do not think a sewing machine manufacturer prior to the war got as much as $11.00 for a machine. My partner in business when I first started was a sewing machine manufacturer. I got these figures from him. But $9.25 or $10.00 was the manufacturer's price for a sewing machine. We know they frequently sell for $50.00 each, and we also know the sewing machine agent is not getting fabulously rich. Look at that difference, $9.50 to $10.00 and $50.00! That is an enormous price to pay for selling a machine simply because we are maintaining a competition that is an expensive way of doing the business.

Another instance is the piano, which the manufacturer sells for from $85.00 to $100.00, and which retails for several hundred dollars. Nobody pretends to say that the piano agent is making an undue amount of profit; he is simply using a method of selling that is expensive.

If some law were substituted for the Sherman law whereby the enormous expense of competitive selling were reduced, the consumer could have a good deal more of this world's comforts and luxuries and the manufacturer would receive no less for his products than he now does. Two or three competitive postal companies do not send several letter carriers on the same street, and we get good service for a little money.

Germany long ago appreciated the enormous waste of competitive selling methods and laws were framed to abolish them. I do not advocate a resumption of the unfair methods that were attributed to the Standard Oil Company in years gone by, but a system for example that would let two milk peddlers agree to each deliver milk on alternate streets would be much superior to the Sherman Law that, if carried out to the letter, would prevent any such arrangement and cause both milk peddlers to travel the full length of each street.

The cost of selling automobiles is now relatively small, because the demand has steadily been ahead of the supply, but a little later, when production overtakes consumption, we are very liable to see the enormous selling expense of sewing machines and pianos reached in the automobile, unless some way is devised whereby sellers can combine to the extent of agreeing to divide territory, or agree to have the consumers go to the store instead of the store going to the consumer.

I can see no reason for doubting our ability to compete, and if we have laws that are equally favorable I am confident that we shall be able to hold our own against foreign competition after the war.

DISCUSSION

A. W. SMITH.—I think the thought that Mr. Dow has brought out tonight

of not being afraid of the Germans is very important to us. I want to add my word of encouragement to anyone who is going into any competition with the Germans in this way: Some time ago there was an article by President Elliott in one of the magazines which stated that there were some inventions made in this country of equal merit to those made in Germany. Not only that, but that many of the greatest inventions had been made outside of Germany. That interested me greatly. I could not believe it at first. I was skeptical. So I made a careful study of the subject. I looked through the encyclopedias and tabulated the names of those who had been prominent in the making of great inventions—epoch-making inventions. I found after a careful study that the United States was first in the list of these names, far ahead of any other nationality; that Great Britain came next; that France came third; that Germany came fourth in the list of these names, and Scandinavia was almost equal to Germany. Therefore, I think that we have some ability in this country to do great things and I want to encourage anyone who has the temerity to think of competing with Germany to go ahead and do it.

In connection with the international German bleach concern; were they ever eventually driven from the American market, or do they still continue to import bleach, or how long did they continue to import bleach?

HERBERT H. DOW.—I think Germany had a very distinct advantage in the manufacture of bleaching powder. They had the mines from which the world's supply of potash was obtained. These mines did not exist in other parts of the world, and in the manufacture of caustic potash from these potash mines they had chlorine as a by-product. That chlorine by-product must be disposed of in some way. It would be a nuisance if it were allowed to escape into the air. It was made into bleaching powder because it was a by-product, and was for a while a somewhat serious competitor, more particularly because they made very low prices over here. But the quality of German bleach never was first class. I do not mean by that to say that the Germans did not have the ability to make a high grade of bleach, but this bleach was not first class, possibly because they did not have the proper lime in Germany, or for some other reason; but the amount sold here was very low, and it ceased to be a factor some years before the war. Whether any at all was coming in I am unable to say, but the amount, at least, was very small, and bleaching powder in the future is not going to be shipped, in all probability, any great distance. The cost of the package and the cost of shipping is so great that in all probability it will be made right at the markets where it is used, especially as it depreciates rapidly, and it is a great advantage to have fresh bleach. On that account Germany was handicapped. For the same reason the American paper mill that wants to bleach its own paper on its own ground has the advantage of putting the bleach plant on their premises. The caustic is a product that is used also by the paper mills; they avoid the cost of the package and of concentrating by making their own caustic soda on the premises. I hardly think bleaching powder would be a fair example. But they were unable to hold the market, although they did have a decided advantage.

C. T. HARRIS.—Mr. Dow, from the reference you made to support of the manufacturers given by the German government, I judge that you have drawn this conclusion: that it is not due so much to any superiority on the part of the German manufacturer, either in chemical knowledge or mechanical ability, that they have been able to take the markets of the world as they have, but it is more largely due to the fact of the support which the German government has

given those manufacturers in their efforts under the system known over there as the "Cartel" system. You referred to the statement the German government made through a representative, or a statement that was made by a German, that they would not allow you to sell a certain line of goods. I know that has been the case in some other lines, that the backing by the German government itself, through its banking interests and its financiers, has been of such a character that the manufacturer has been supported in the development of his line. The government has built up its industries and backed them financially to the limit all over the world; whereas in this country our government has not only not encouraged, but on the other hand has rather hindered and made illegal a development of that character. There has been more due to the German "Cartel" system of supporting the development of its industries than to any superiority on the part of the German himself to develop his industry.

Herbert H. Dow. During the time that we had this competition on bromides, we were invited to visit Germany, and visit one of their great plants, and it was probably not a coincidence that we visited the Prussian government plant. They were very free to tell us that this particular potash mine in which bromine was made was a Prussian government mine. It was undoubtedly a very well-conducted, elaborate and first-class mining proposition in every respect, so far as I am able to judge. But the point they endeavored to impress upon us was the fact that it was government property and that the government was back of it, that the government was going to see them through, and that we were insignificant in comparison. I do not doubt but that in years gone by a lot of people hesitated to compete with the Standard Oil Company, not because they were unable to use as good methods as the Standard Oil Company was able to use, but they were afraid to. They said, "What is the use; we will get put out of business?" In the same way, the fact that it is controlled by a "Cartel" or by a convention as they sometimes call them over there, made people afraid, especially if the Prussian government was a party to that convention; they were afraid to engage in manufacturing because, they said, "What is the use? They have a record of destroying their competitors; we don't want to go in there and just make a mark of ourselves. They will concentrate on us, and that will be the end of it."

Now, I am not advocating the repeal of the Sherman law, and the permission granted to Americans to go out and by ruthless methods destroy their competitors; but there must be a middle ground somewhere that will be of advantage for all parties concerned, fully as much to the consumer as to the producer and eliminate many of these expensive selling methods.

In the United States we have a system where we have to educate everybody, more or less, whereas in Germany they only have to educate the few in order to take advantage of a good proposition. I think they have the good proposition over there. I think that we are sufficiently intelligent so that after campaigning and advertising and educating, we in the United States will also have those advantageous methods. I hope it will be brought forward and advocated and it seems to me a body like this is an ideal body to promulgate ideas of that kind, to see the injustice and enormous expense to the consumer of these expensive selling and delivery methods.

Take for example the post office system. If you had ten or a dozen different letter carriers on your street, what would it cost to deliver mail as compared with one letter carrier delivering to every house? That is only an example. That can be multiplied a hundred times over in regard

to every company that is using competitive methods.

J. E. Washburn. What line of chemicals are now being manufactured and have been developed since the war that were necessitated by the war, due to the fact that the supplies have been cut off from the warring countries?

Herbert H. Dow.—Germany undoubtedly excelled in the manufacture of organic chemicals. I do not think they excelled in the manufacture of any chemicals except organic. Take, for instance, soda-ash, the manufacture of salt and hundreds of things that are manufactured in large amounts, we have been able not only to compete in neutral countries, but have been able to sell in Hamburg. It maybe of interest to you to know that we have been able to get two cents a pound more for bromides sold in Japan by the way of Hamburg than we would for those same bromides shipped directly from the Pacific coast. Now, that was not because of superior manufacturing methods of the Germans, that was because of superior advertising methods of the Germans. We think we are pretty good advertisers over here; we are greenhorns at it. We do not know how.

I do not think I answered your question. Dyes to produce every color are now made in the United States. There is one class of dyes, the Indoxyl dyes, that are very stable, that are as stable as indigo, or even more so, that is not made at the present time in the United States. The patents have not yet expired, except perhaps on one or two colors, and it is a somewhat complicated color to make. It may be a year or two before we will be making the Indoxyl colors in the United States, and if the patent laws prevent, it may be a greater length of time. But I think, aside from the Indoxyls, the United States is making every color for which there is any great demand, and they are filling the normal requirements of the trade with colors fully as brilliant and fully as good in every way, except this particular color is in many cases a little more permanent than the corresponding shades that we are now making. We had to go up through the same development stage in the manufacture of colors that Germany herself did, to some extent. We manufactured the simpler colors first. The simpler dyes that were more easily made we gradually replaced by dyes that had advantage over the more easily made dyes. As the knowledge of the manufacturer of these dyes progresses, we will continue to make better and better dyes, but at the present time there is nothing serious in the dye situation. The United States is not going to be handicapped materially by reason of her inability to get a dye. Most Americans wear clothes that get out of style long before they fade very much.

Now, there are three or four important medicinal compounds formerly made in Germany and made nowhere else. These have been protected by patents. Salvarsan is one of them. It is now manufactured in Ann Arbor and I presume in a number of other places in the United States. We know how to make it over here. It is just a question of patents, and whether people care to engage in this work or not.

The tremendous impetus war has given to the manufacturer of explosives will give us a latent power when these explosives are no longer needed, because of the fact that the explosive manufacturing plants, or the chemical plants in which these explosives are made, are very similar to the plants in which dyes are made. For example, we manufacture di-nitrophenol. It only takes one step more to convert that into picric acid, a high explosive, or sulphur black, one of the most stable blacks. If that di-nitro-phenol is nitrated, it becomes picric acid. If it is treated with sulphide of soda, boiled with it under

a little more pressure than you get from the atmosphere, in an enclosed vessel, it goes to sulphur black.

That example may exaggerate this idea a little, because there is a great amount of work in making the di-nitro-phenol, and it is only just one step to make either the dye or the explosive. In many cases it is not so easy. Analine is a nitrate product and every explosive that is used as a propellant is also a nitrate product. The manufacture of nitric acid depends on the manufacture of sulphuric acid, and that, at the present time at least, depends on sulphur. We have the greatest supply of sulphur of any nation in the world, and I presume we have cheaper sulphur in the United States, cheaper at least to get, than they have anywhere else, unless it is Sicily, and I think it is cheaper than in Sicily. The nitrate itself mostly comes from Chile. There is no reason why Chile saltpeter should cost us more than it costs Germany; in fact, it costs us less. The sulphur costs us less, and the benzol, the other raw material that is used in the manufacture of analine is the first distillate from tar, which is similar to gasoline. It is a very light, boiling liquid that looks like gasoline, and can be used in automobiles to replace gasoline. It is now being produced in the United States from by-product coke ovens in an enormous amount and much more than is required in the dye industry. Now, when the war is over, that benzol will have to compete with gasoline, which is cheaper in the United States than Europe. That means benzol will be cheaper in the United States than Europe. Sulphur, nitre and benzol, three raw materials, all of them cheaper here. If they are used in very large quantity, labor becomes a minor factor after you have once mastered the process and know how to use them on a big scale. And whether you pay a man one dollar a day or ten dollars a day, is not very important. Suppose, for example, he is distilling five hundred or a thousand dollars' worth of product a day, it does not make a very vital difference what his wages are.

John McGeorge.—What about the photographic chemicals, particularly the developers?

Herbert H. Dow.—We know a little about that, because we are supplying the Eastman Kodak Company with some of their raw material, and we were asked to make some of these compounds. The price was very high, and I think still on some of the compounds the price is high. But the principal developers are now being made in the United States, and presumably the makers are getting a big profit. I do not know whether they are or are not, but I guess they are. It is only a question of time until competition will start, I think the competition is coming, and when the German competition starts you will see the American price go down at a tremendous rate.

John McGeorge.—A number of years ago I was up in Midland, and we were speaking of one product, bromide potassium. Mr. Dow asked what I was paying for it. He knew I was using it in photography. You ought to have seen the envy that went over his face when he heard what I was paying for it. He gave me a vial of it, and I still have some of that left.

W. R. Mott. — It has interested me greatly to hear this address by our esteemed speaker. I quite agree with what he and Dr. Smith said about the Germans. We greatly overestimate their intelligence and their cleverness. I made a search about fifteen years ago covering the entire literature on aluminum anodes, lightning arresters and rectifiers, etc. I read all the English, German, French and Italian literature. I found that the Americans and the French had anticipated the Germans in the inventions in these lines by about ten to twenty-five years, but that the Germans had taken the scientific world by storm as having

invented it. The man I refer to was Bottome (U. S. Pat. 458,652, Sept. 1, 1891), the American inventor of the aluminum four-cell rectifier. The French inventor was Cael, who discovered the value of sulphate, chromate and phosphate solutions for rectification of currents with aluminum anodes. (See Cael, Annales Telegraphiques, vol. III, pages 250, May-June, 1876.) However, Graetz, the German inventor, without referring to the work of Bottome or Cael, claims credit for their essential results. (See Zietschrift fur Elektrochemie, vol. 4, page 67, 1897.) The situation is that Graetz is given credit throughout the world for results first obtained in America and France many years earlier. (This is probably the result of the good abstracting system of the Germans.) The Germans are good imitators. They are like the ancient Greeks: they take the information that other people have and they are willing to improve upon it.

In going over this literature I ran across certain characteristics that may be of interest. I will mention them very briefly. The Germans, it seems to me, have the power to do creative thinking along lines of essential similarity. The French excel in the study of elements of essential differences. The Italians excel in thought structure parallel to the plot and counter plot—a balancing of opposing factors. The Russians excel in drawing conclusions by the use of the close relation of properties at the two extremes of a series. The Americans excel in initiative and resourcefulness of their creative work. The English excel in aggressiveness and persistence.

The dominant characteristic of the German literature is its enormous volume and its enormous power of abstracting all the other literature of the world. If there is anything in the abstract way that you want, you go to the German literature with its specialized journals, handbooks and dictionaries in every line. About ten years ago we started in the American Chemical Society one of the best abstracting journals in the world. We have room for similar abstract journals along other lines.

I believe we ought to study all the chemical processes just as aggressively as all the mechanical processes. I believe the American genius in chemistry can be just as great as in any other line. I think there are any number of new chemicals and new reactions that will be worked out by Americans in the near future.

H. E. Hackenberg.—While my name is doubtless of German origin, my sentiments are not German, as my associates, I am sure, will testify.

I had the pleasure of accompanying Mr. Dow on one of his trips to Germany, and I can confirm all that he said about that trip. I had an interesting experience in Berlin. I had a letter of introduction to Dr. Rathnau, who was, at that time the president of the Allgemeine Electricitaats Gesellschaft, and he asked me if I would not like to meet one of our competitors in the carbon business. I told him that I would be glad to do so, and he sent me over to see the managing director of the carbon works, whose office was located in Berlin, but whose works were in Austria. And, by the way, notwithstanding my German name, I had to take with me an interpreter in order to carry on a satisfactory conversation with this carbon manufacturer. After a little preliminary conversation, he said: "Mr. Hackenberg, you need not tell me what you manufacture, the different grades of carbons and batteries, because I already know, as I grant that you perhaps are the leading manufacturer in the United States, but I really do not think that as time goes on you will continue to be unless you make some alliance with a German manufacturer."

He said: "Now, we procure every two or three months samples of your products. You make a fair enclosed arc lighting carbon," and then he went down the list; "but," he said, "you are not making perfect goods like we do here." And he wound up by suggesting that it would be to our advantage to make some arrangements with his company. He said that unless we did he was going to ship his product to the United States. He said, "I do not care anything about your tariffs, I do not care anything about the freight and insurance we have to pay, we can manufacture our goods, we can pay all the expenses of getting them to the United States, we can undersell you, and we can make more profit than you are now making yourselves." I told him that I had some doubts about that. But he said that he did not. He said, "You pay for common labor, say $1.75 or $2.00 a day, do you not?" and I said, "Yes." At that time those figures were correct. He said, "We pay about one-third or one-fourth of that," and he was correct in that. I found upon investigation that the prices they were paying for labor at Ratibor were just the figures that he gave me. Well, perhaps it is a fortunate thing that this war came on, because if the line of talk that he gave me was true, the National Carbon Company would probably be out of business today.

But I agree with Mr. Dow most perfectly in that we have in this country just as good brains, just as active, as they have in Germany or any other country on the face of the globe. The American manufacturer in any line is going to compete with the Germans or the manufacturers of any other nation. All that we want is fair play. We want to be able to market our products on just as favorable conditions as the Germans or any others.

Now, in South America, for instance, where, by the way, we are developing quite a large trade, the Germans did have and still have the advantage of the American manufacturers, and it may be that after this war they will still have the advantage, unless the United States will modify some of the laws that are now on the statute books, as Mr. Dow has suggested.

John McGeorge.—May I ask one more question which can be answered by either Mr. Dow or Mr. Hackenberg. Was there anything in the cry that came just after the war that we could not get good carbons for lantern work? I know I got some carbons for my lantern which gave me a great amount of trouble, and when I went for better carbons they told me they were not to be had, that all of the good carbons came from across the water and we could not get the good carbons here. Was there anything in that cry or not?

H. E. Hackenberg.—There was a time when, we will all admit, the best carbons for certain purposes came from the other side, but that condition has not prevailed for some years as I think the users of all kinds of carbons in the United States will testify at this time. As I said before, I think we have in America just as good brains as they have on the other side of the water, and not only that, but I am very sure that we have in our establishment just as good brains in the making of carbons as they ever did have or ever will have in Germany or any other European country.

Herbert H. Dow.—Mr. Chairman, may I say a word about that. I think that is a typical example right here. They only use a very few carbons for the particular kind of work that you referred to. It does not pay the American, with his high prices, high salaried research men, to make a dozen or a hundred of some very fancy variety of carbon, that is, a high-priced article that only has a very limited use. That applies to these dyes that are only used in very small amounts, or a chemical that is only used in a very small amount. I do

not think the Germans will have any difficulty in being able to again dominate the market in any chemical that is only used to the extent of two or three hundred dollars a year. Americans do not care about monkeying around with that kind of business. They get too big salaries over here to fool around with that kind of business. The whole point of my article was, when it comes to manufacturing where a large amount of material is handled on a big scale, we have the tricks of the trade with us. They have to have something for their chemists over there; we will let them make those things.

Machine Shops and the War

By Fred H. Colvin*

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My only excuse for addressing you this evening is that circumstances have perhaps enabled me to see many of the activities of war preparation at close range, and to get a more diversified view of the situation than would have been possible without being located in Washington much of the time since we entered the war.

First of all, however, I want to try to make you feel as strongly as I do the necessity for our actually realizing that we are at war, and, so far as we can, 3,000 miles away, to feel and to realize what this war means. Too many men whom I meet seem to think that, so long as all the fighting is being done on the other side, all we need to do is to read the newspapers and pay our taxes; some even object to that.

I want to make you feel as I feel, that Pershing and his army, no matter how large it may eventually be, are only the vanguard, only the skirmish line, if you will, and that the main army, the army which must ultimately win this war, is here in the United States. No matter how able Pershing may be, no matter how brave and how well drilled his troops, they cannot possibly win unless everyone of us on this side does his full duty. For you men in the shop, or in the office, or in any other capacity, who are working directly or indirectly to produce the various munitions of war, are the real army, and if you fail, Pershing cannot possibly win.

Being so far away makes it difficult for us to realize our direct connection, but we should ask ourselves every day, "What have we done and what can we do?" I do not believe there is a more peacefully inclined man than I in the United States or elsewhere, and I was extremely reluctant to be drawn into the struggle; but now that we are in, the time for argument has passed and it is up to us to leave no stone unturned that will assist our boys over there.

What can the machine shops do?

They must do many things, and they must learn to look at the whole problem in a different light. The old individualistic idea of peace times must be set aside. It is no longer a case of your shop and my shop, but of our shops as a part of the whole productive mechanism of this country. We are faced with the problem of greatly increasing production with a decreasing force of men and a lessening percentage of those men being highly skilled.

The draft has taken many who ought still to be in your shops. The red tape of the army and the desire to avoid any show of favoritism is responsible for much of the present disorganization of our shops. I could cite many instances, but you know of them as well as I. The only redeeming feature is that, according to present plans, these men are to be detailed to the repair shops which are being established behind the lines in France; and as these repair shops will require many thousands of men, the skill which has been acquired is not being entirely lost.

The main and only problem is increased production, and, while we all know how the word "efficiency" has been overworked and what expensive experiments have been made along this line, it is up to us to make the word really mean something, both to aid in our conduct of the war and in the reconstruction period which is

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to follow. We must be ready to further production by every method which proves successful, no matter how badly it interferes with any of our former prejudices.

There is one feature concerning production, both present and future, which we are all too apt to overlook, and this is the proper training of not only the youth but of the workmen in the shop. Proper, practical education is more necessary than ever, and it would be a vital mistake to drop any of the educational features from our shops. They should in fact be increased and extended so far as possible to all the workers therein; and this not only for the present, but particularly for the future, for we shall face a world well trained by the worst kind of adversity, and in some cases well equipped to meet all our products.

There is also another factor which is already being considered, even in some of the most conservative sections of the country. This is the employment of women in the machine shops on regular machine operations, and it is interesting to note that with few exceptions they are doing remarkably well. As a result of numerous observations made last summer, it seems safe to state that for equal strength, equal intelligence and equal experience, there is practically no difference either in the training or in the output of either men or women. In one Canadian shop running three shifts of eight hours each, about 700 out of 1000 people in each shift were women. They were handling practically every type of machine in the shop, working side by side with the men in many cases, and, as a rule, earning more money per week at the same piece price. For the rule of equal pay for equal work seems to be quite firmly established in both shops, and rightly so. Should it become necessary to employ women more extensively, it is safe to say that intelligent handling will secure good results in most cases.

We are all too apt to think of longer hours when we mention increased production. But in the light of modern experience and profiting by the examples of England and other countries, it frequently happens that production can be increased by shortening the work-day. If, however, we can keep the machines running 16, or even 24 hours a day, as is being done in many cases, we are working along the right lines.

It is, of course, difficult to see how this can be done in view of the difficulty many shops have of securing sufficient men for a single shift. Here, however, the question of shop management comes into play and the great problem of labor turnovers plays an important part. I know of one instance where two shops of approximately the same size and in the same town have such different working conditions and such different shop management that one has a monthly turnover of from 200 to 300 men, while the average of the other shop is only four for the same period.

It is the observation of some of the best posted men I know in the employment business that there is no real shortage of man-power at the present time. The great difficulty seems to be in the labor turnover and in the fact that even an ordinary workman can demand extremely high pay if he waits a few days for some particular job. This condition has been fostered to some extent by the awarding of contracts on the cost-plus basis. And, while it is probably necessary to award many contracts in this way, it seems as though there must be some limit put on the price which can be paid for labor, or it will have a disastrous effect on other industries which may be equally necessary.

When, however, we begin to adopt the price-fixing plan, we are treading on dangerous ground. We must not, however, overlook the fact that we cannot fix the wage of the workman without at the same time fixing the

price he must pay for food, rent and clothes. And, if we attempt to fix his maximum wage, we must also fix a maximum salary and the maximum income of everyone. We must improve our shop methods; we must increase our interchange of ideas from shop to shop; we must realize that both the cost and the amount of production are inevitably tied up with the time required.

We must also remember that all of the difficulties of price regulation would practically disappear if we could make every man, woman and child of the country actually feel that the one thing that should be uppermost in our minds is to win the war. And if they can be imbued with this feeling there will be no question which cannot be solved by mutual concession and without in any way delaying production.

In closing may I suggest that you bear in mind that one of the great needs of the country is that the engineer take a more active part in both the making and the enforcing of its laws. This is an engineering age, and whether you like it or not, it is a part of the engineer's duty to serve his country in any way for which his training and experience fits him. I also must repeat that our first duty at the present time is to make ourselves feel that we are a vital part of this war, that this is the one great task before us at the present time, and that we should concentrate our efforts to that end.

DISCUSSION

E. B. THOMAS.—Do you care to express yourself, Mr. Colvin, as to the plant capacity of the country and the probable requirements of the army and navy?

FRED H. COLVIN.—That includes so many things. It includes drills and presses and boring machines. When it comes to having shell capacity enough, I do not think we have. The unfortunate part is that a lot of our plants which did make shells for the Allies a year ago have been dismantled for the reason that no orders were coming in, and, although the ordnance department did in some cases retain men with pay, they did not retain these plants. We must build up a capacity, I believe, of at least 250,000 shells a day of all calibers. We have never had that in this country. The biggest we had I think supposedly was about 150,000 shells a day. That means also of a larger caliber than we used before. In the beginning of the war the three-inch shell was almost 90 per cent of the shells. I think the next two years will see the great majority of them six-inch or larger. That means more time and more work.

JOHN MCGEORGE.—What percentage of the ammunition is held to close limits?

FRED H. COLVIN.—About 101 per cent. I think a great deal of it is unnecessary, and I may say in that respect, from the drawings I know of, our French friends were extremely sensible in specifications and almost everything else. In the beginning of the war, for the three-inch shells the British specifications demanded that each shell have a dust cap to go in in place of the fuse until it was loaded. In some cases that was demanded of zinc and in other cases of brass. Zinc could not be obtained; there was not enough zinc in the country, and they finally made them of brass and later of steel. After about a year they began making them of wood, that was a threaded cap of wood, generally birch, and they demanded limits on those, very close limits. The French, in the meantime, drove a bung in the end, which kept the dust out just as well as the brass cap.

E. B. THOMAS.—Is the cost-plus system on the increase or decrease?

FRED H. COLVIN.—I do not know that I can say. There are some contracts that it seems impossible to let any other way. Take the large gun contracts. Now, in this country we only had about four shops which had

made guns outside of the arsenals. They are being made now in a dozen other plants that never before made guns at all. How else could we do it? And yet it is a dangerous proposition.

The aeroplane proposition may interest you a little, possibly. The general plan is that we in this country are going to devote ourselves mostly to the big bombing machines, with some reconnaissance machines, the reason being that the styles in the small, fast machines change more often than do those of women's bonnets, and we are too far away to keep up with the styles there. The French designed machine is captured occasionally by the Germans, and they copy it or improve on it, and their machine drops over in the other man's lines, and the other fellow does the same thing.

But it means tremendous powers. For example, the big Liberty motor, as you know, will develop approximately 400 horsepower. Those are being built in large quantities. Besides that, we are building all the other types, and we are doing that, I think, sensibly. The aviator is a good deal like a horse jockey; he is a man that you humor, because he is doing dangerous work, and he is not over plentiful. So you give him the kind of a motor he knows and likes. It takes a peculiar temperament to be a successful army flier. Most of the war in the air is being done by men under twenty-five years old; they not only have to be aviators but machine gunners, photographers, wireless operators, map makers, and several other things. Furthermore, they must be able to stand the high altitudes, because today they are doing a great deal of their fighting at 20,000 feet and over, approximately four miles.

E. E. Blundell.—Mr. Colvin, in this cost-plus proposition, is there no limit at all to the rate of wages that they can pay to the men?

Fred H. Colvin.—I do not know that it is limited. I do not know whether it is to be or not.

E. E. Blundell.—It seems to me if they were allowed to pay any amount at all, they could pay a dollar an hour and make more money on it than if they paid fifty cents.

Fred H. Colvin.—That is the danger. A dollar an hour is not high at all in a lot of places. Two years ago I saw an Italian ex-barber who had been in the shop about a month, turning copper bands on three-inch shells. They happened to be Italian shells, and they estimated that he could do 150 a day, so they set the price at three cents each, and he was doing six hundred every ten hours, which is a fair wage for a barber. In some cases the Westinghouse Company in Pittsburgh, I am told, had men that earned as high as thirty-three dollars a day on that sort of thing. The Italian soldier in the trenches was getting six cents a day at the same time, and if he lives to come home, his taxes will have to pay that other fellow his eighteen dollars. I do not know that there is any limit. I do not see how you can limit it. On the other hand, they are not supposed to pay more than is necessary to get the men, but if the other man bids nine dollars, they must bid ten to get him, unless there is something to regulate it later.

Member.—Is the government going to have auditors in these plants?

Fred H. Colvin.—They have auditors in the plants. Incidentally I might say it is increasing the clerical work quite a little in the plants.

K. H. Osborn.—Is the munition work increasing the use of the metric system?

Fred H. Colvin.—For artillery and ammunition we have adopted the French guns, and that means, of course, the metric. Whether it will be translated before going out to our shops generally or not I do not know. But we have adopted the French field artillery, that is, the 75, and the 155, and I think the 220. Above that I

believe is the 9.2. I think 9.2 is the British size.

JOHN MCGEORGE.—You spoke of conscription in all branches. Is not regulation of wages one of the forms of conscription that is going to come?

FRED H. COLVIN.—I think it must. It does not benefit a man to get an increase in wages if everything else jumps faster than his increase, or even as fast. One plan which I understand they are using in England is that they have about two hundred thousand men that they call enlisted labor, I think. I do not remember the exact name they give to it. Floating mechanics, you might say, who volunteer to go to any place in the Kingdom that they are needed. Living conditions over there vary, I am told, in the different towns. Now, these men get, I believe, a fixed wage, but if they come to a town where living conditions are higher, the government gives them an allowance making the difference, not as an increase in wage, but, as you might say, living expenses there covering the difference at that town.

JOHN MCGEORGE.—In the English advertisements for men, particularly for designers and draftsmen, distinct notice is given that no one already in government employ need apply.

FRED H. COLVIN.—They have, I believe, something to the effect that you cannot hire a man unless he brings a certificate giving his last employment, and also, I believe, the reason he left, and all signed by the employer. That is, in other words, a release. There is, I understand, going into our contracts here a clause stating that you cannot employ a man who has worked in any other plant doing government work during the last sixty days. That is, in other words, he must loaf sixty days if he leaves one plant before he can go to another.

M. F. LOOMIS.—Do you expect our government to bring any pressure to bear on the non-essential industries to produce labor?

FRED H. COLVIN.—I do. One thing may interest you a little that has been talked about, and that is platinum, and, the industries using platinum, mostly jewelers, of course. There is talk about either commandeering platinum or else taxing it 25 per cent a year—rings, or anything else of that kind. You see, platinum is absolutely necessary for chemists' appliances, crucibles and things of that kind. I believe they are used a great deal in making analyses. That was being discussed in Washington several months ago. I think the candy industry will be curtailed very greatly.

M. F. LOOMIS.—By what means within the law can the non-essential industries be curtailed?

FRED H. COLVIN.—I do not know that they can under any existing laws, but they are going to have our law mill in operation next month, you know.

M. F. LOOMIS.—How about shortening the coal and power?

FRED H. COLVIN.—I think they are going to do that. One interesting example of that happened up in Camp Devens at Ayer, Mass., which is a large camp for about forty or fifty thousand men. They are getting power from the Connecticut river, and that we always considered was unlimited, without thinking much about it. I understand they are equipped there to do everything electrically, even cooking. And this means that some industries I know of, a hundred miles away, cannot get any more power for their increased business than they are now getting, which must be changed, of course. That is simply an indication of the way one thing interlocks with another all over the country.

MEMBER.—Getting back to the aeroplane. You said they were doing the fighting at 20,000 feet.

FRED H. COLVIN.—Yes.

MEMBER.—What is the object in doing it so high?

FRED H. COLVIN.—One reason is to get out of the range of anti-aircraft guns

Member.—They are trying to get on top of the other fellow?

Fred H. Colvin.—Each one generally tries to get above the other, although in some cases a number of them prefer to get up underneath and shoot. They all have their own tricks about doing those things, and it is wonderful what is done. I met up in Canada last year an English captain who was wounded over on the other side. He was carrying a shrapnel ball in his head, which he has had removed since. He said he was wounded when about 12,000 feet in the air, and he did not know how he landed. The next thing he knew he woke up in the hospital. But he evidently had kept senses enough to make a landing.

He told me another interesting thing, if you will pardon me just a moment. He was speaking of a type of machine they had developed over there. I do not remember the exact name. He said he had flown those machines from England over to France, as they do right along, and from the time he got up into the air until he was over in France ready to make his landing, he never touched his machine, except the lever. In fact, he said he read a book all the way over.

G. F. Collister. — Do you believe that there is a definite plan working out now to force classes of manufacture that are not making material necessary for the carrying on of war at the present time, to discontinue their present manufacture, and to turn into the manufacture of government material, such as in the automobile industries who use a great quantity of chrome vanadium and chrome nickel steels. The mills are not allowed to take orders now for shipment of chrome steel for any other than government use. Is that aimed to cut out that class of manufacture, or is it aimed only to conserve chromium?

Fred H. Colvin.—I think it is mostly to conserve chromium. That is only my guess, you understand. I do not stand next to all the high powers in Washington. But the pleasure car, in my opinion, will decrease in output, I think, because the factories will be requested to do some things that are possibly more necessary. That is, I think, true of a number of the big companies right now. I think plans are contemplated to control a lot of them. They will not be put into effect unless it becomes absolutely necessary, I am very sure.

G. F. Collister.—They are surely getting the result in an indirect way, there is no doubt about that.

John McGeorge.—I saw a statement the other day in one of the papers that a certain order for war machinery—it did not give prices—had been placed and divided among at least five manufacturers, and each of those five manufacturers had to make the complete article, necessitating nearly $500,000,000 worth of fixtures and gages, where if it had been properly divided it would have taken only about one-fifth of that amount.

Fred H. Colvin.—Yes, I know what you mean.

John McGeorge.—Is that true?

Fred H. Colvin.—I am afraid it is. I do not know positively, but I am told it is on very good authority. It is one of the things again that would not have been done with competent engineers on the job.

There is one other thing I might mention, and that is that there is an attempt being made in some quarters to secure machinery under false pretenses, that is, by intimating or even getting possibly priority certificates, and it does seem to me that anybody who does that is, to put it mildly, unpatriotic. It is possible we can do a lot to prevent things of that kind when they do come up to us, by expressing ourselves very freely about it. There are men today who do not hesitate at all to pick up a thousand dollars or less on things that delay production, and that means boys on the other side are going to be killed.

It means lives lost every day it goes on. And it does not take a very long analysis to easily show that the man who does that, and who delays things, comes pretty nearly killing the men over there.

Member.—To what extent is production delayed by incompetent inspection?

Fred H. Colvin.—Inspectors generally follow definite rules laid down, with no discretion themselves at all. I am told that in Bridgeport, at the time the British needed bayonets the worst way, thousands were rejected because they were a thousandth of an inch too thin. Foundations down there are said to be reinforced, many of them, with discarded bayonets, which are perfectly good. And that exists today. The inspectors do not have discretion, and in many cases they would not know anything about it if they did have it.

Member.—That is due largely to a spirit of distrust, too, I think.

Fred H. Colvin.—Yes. It all gets back to the manufacturer who some time in the past tried to "do" the government. Specifications are built up so that that cannot happen.

J. A. Williams.—Do you know whether or not the enemy countries were as tangled up as we are at this stage of the game?

Fred H. Colvin.—I do not believe they were. Their job was untangled along back in 1870, apparently.

Member.—What is your view of the variation allowed by the government on threads?

Fred H. Colvin.—It depends on what they are for entirely. For fuse threads I think they are ridiculously close. When you realize a fuse screws into a shell once, you do not do any repairing of it at all; it goes in once and it simply resists the inertia, the turning inertia of the mass of the fuse. I saw one case of 20,000 fuses rejected because a snap gauge put over the top of the thread, which never ought to be done anyhow, was one-thousandth of an inch too small. A half a thread or a quarter would hold amply well for it, and they were ridiculously close.

I. D. Thomas.—Were the foreign inspectors as close as our own inspectors in this country in their restrictions?

Fred H. Colvin.—That depends a lot on the inspector. I know one instance which may interest you, possibly, in an aeroplane factory. This was a British order and the inspector was very particular. He had put his reject mark on a great many parts that were perfectly good. The builder did not obejct because he knew they were all right, and they used them in their regular product. But it so happened that one day they had an engine on the test block which was showing remarkably well. It was built almost entirely of this inspector's rejects. And he came along and saw that it was doing well and he said, "I want this engine." The superintendent attempted to explain to him that it was made from rejects, but he said, "I want that engine. It is a good engine and you are trying to keep it away from me." So it was boxed and shipped. It was too good a joke, of course, and some of the boys in the shop finally told the inspector. And then he went up in the air. He said, "The motor was pretty good, I guess, but what will they say on the other side when they overhaul it and see my reject marks on every piece?"

Inspection, even in your own shops, is not an easy problem. And when you take, as you must take now, thousands of men who are not familiar with these products, even if they all do their best, there is going to be trouble. Many of you know what it is in your own shop, even if it is a small shop. Inspection is one of our worst problems in manufacturing, I believe. My contention is that you ought to make tolerances just as big as you can, and in that way pass all that you can that will properly function. To me there should be just

one main thing to consider: Will it function properly? Outside of that, pass as much as you can.

JOHN McGEORGE.—May I say a word, not in defense of the inspectors, but rather a word of caution to manufacturers? My only experience in inspecting was a number of years ago. It was an ice-making machine for Panama. I had the honor of inspecting that machine from beginning to end. My first step in getting down to St. Louis, where the machine was being built, was to investigate the conditions in the shop where it was to be built, in comparison with specifications they had. There is only one point I want to mention. The cylinders were specified to be made of cold blast iron. I quietly, amongst other inquiries, inquired around as to what they had been using in the foundry where they were made. And as a result of my investigations, that and several other points, I wrote immediately to headquarters pointing out that those specifications could not be lived up to, and if they attempted to do it they would get a far worse job. I suppose my inquiry was a little pointed, as evidenced by my next visit. On my second visit, I got a telegram from the government authorizing me to use my own judgment absolutely. The minute I got in the shop I came across a director whom I had not seen on the first visit. He started in rather rough language and said that he was not going to be ruined, he would not sign the contract. I told him I did not care whether he signed the contract or not. I said, "There is the bid, and there is the acceptance." He had (to make his specifications look big) specified materials he could not and did not intend to use. He was very humble when I showed him the telegram I had received. I want to emphasize that, because it points to the conclusion you mentioned a short time ago. It goes back to the manufacturer who tried to do the government. That man had no intention of living up to his specifications. That is only one point. There were other points just as bad in those specifications. If it had not been for the authority I received to use my own judgment, he would have been wrong on that job, because he could not have filled it.

C. O. PALMER.—A short time ago a maker of rare elements that go into steel to increase its tensile strength, said that the government was trying to improve the steel by alloying it differently. In flying machines, he said that in Europe they had to make them so light that they very materially reduced the factor of safety. Of course they try to increase the strength of the material as much as possible.

FRED H. COLVIN.—The Bureau of Standards in Washington is constantly making investigations with alloys. This is not the alloy, but an indication of what they do. As a result of an experiment with making optical glass, we are making in this country today optical glass I am told just as good as ever came from the other side, and while they are not making as much as they actually need, they are going a long way toward it.

You were speaking of the lightness of the aeroplanes. The fast scouting machines on the other side, I am told, sometimes only have a factor of safety of one and one-half, and sometimes two. We have not done that in this country as yet. The fastest machines we have built are not so fast as those. They have a factor of safety of about four to six. Of course, they say over there that you might just as well get killed by your machine going to pieces as to have the other fellow overtake you and shoot you full of holes, so take your choice.

E. B. THOMAS.—I would like to ask Mr. Colvin, after these things are all manufactured and ready to go across, do you have any fears of water transportation?

FRED H. COLVIN.—That is the neck of the bottle now. It is going to improve materially by spring.

A. L. ANGELL.—How much difference is there between the training planes and the regular fighting planes?

FRED H. COLVIN.—The training planes are built to get off the ground and to land at a comparatively low speed, as low as possible, in other words. The lowest I know of is about 37 miles an hour. That means, of course, the wing is big in comparison to the power the engine has. In fact, they are running in those about 100 horsepower motors, and the wing spread is, I think, 42 feet. Now, the fighting plane, that is, the fast scouting plane, has a wing spread of not over twenty-two feet, and in the case of the Curtiss triplane, the wing is only twenty-four inches wide, and it carries 110 to 150-horsepower motor. Now, the maximum speed of these training machines is about seventy miles an hour, sixty-five, seventy or seventy-five, and the machine today that cannot make 100 to 120 is not in it when it comes to fighting. It is all a question of power.

E. H. LOUGHRIDGE.—I saw in a moving picture show the other night a machine by Mr. Beechey, in which he got the action of all the crankiness of the air on a machine that did not leave the ground. Do you know whether that is being used?

FRED H. COLVIN.—Training machine, you mean?

E. H. LOUGHRIDGE.—Yes.

FRED H. COLVIN.—I have seen illustrations of that. I do not know that it is being used. It may be. The flying camps that I know of go up in the air. In the old days they used to begin with what they call a penguin or a "Lizzie" the boys called it, that is a machine that had clipped wings that could not get off the ground, or at least not over a foot or so. They "taxied", as they called it, around the lot there and just learned the controls. But that was mostly in the days before machines carried more than one man. But today most of the larger machines, all that I know of, are double machines with the two controls. The student goes up with an instructor, and then gradually takes over the control in the air. One of the first stunts they often do is to take a man up five or six thousand feet, and then nose dive with him two or three thousand feet to see if he has any nerve. If he has not, he is no good for that business.

Society Notes

BOOK REVIEWS

THE IRON ORES OF LAKE SUPERIOR

By Crowell & Murray, Perry-Payne building, Cleveland.

Published by the Penton Publishing Co., Cleveland; $3.50 per copy, postpaid.

The third edition of "The Iron Ores of Lake Superior", like the first two editions, contains a history of the Lake Superior region, and also chapters on the geology, mineralogy, production and classification of the ores of the various Lake Superior ranges. Other topics dealt with are transportation, dock equipment at the various ports, valuation of ores, beneficiation of ores, methods of analysis, etc. Certain phases of the subject are covered by original papers by well known men. All the material has been brought up to date and greatly amplified. The final 200 pages are devoted to data and descriptions of the mines on the Lake Superior ranges. New mines which have been opened up since the publication of the second edition of the work are described and located on the maps which illustrate this section of the book.

BUSINESS LAW FOR ENGINEERS

By Prof. C. Frank Allen. McGraw-Hill Book Co., publishers.

Professor Allen's book is well worth while both for reading and reference but as he states in the preface not intended to make every reader his own lawyer.

The law has been said to be classified common sense, nevertheless the recorded classification is so laden with detail of reasoning and citation to authority, necessary to connect up the circumstances of the given case with those of decided cases upon which for stability reliance must be placed that the underlying principles are buried to the lay reader.

The author, in Part I, has stripped these principles of this detail and clearly set out the common law principles underlying the several subjects of relation involving the rights, duties and responsibilities of parties to ordinary business transactions.

A special chapter upon the legal relations of the engineer to clients, third parties and the engineer as an expert witness is good.

In the second part of the book the various steps of contract letting is illustrated by numerous examples taken from actual construction projects with comments by the author and various reasons both of custom and statutory requirements.

HOW TO MAKE LOW PRESSURE TRANSFORMERS

Third edition. Price, postpaid, in cloth covers, 40 cents.

There has been so great a demand for this book that Prof. F. E. Austin, the author, has prepared a third edition, each edition containing more data than the one preceding. As most of the electrical toys, miniature lamps, medical coils, bells, etc., require a current of low voltage, it has been the custom to use batteries to operate them. This book shows how small transformers can be easily and cheaply constructed, which can be connected to an ordinary electric lamp socket. They can be arranged to give different voltages, and will very successfully operate small electric devices, at a fraction of the cost when batteries are used.

The increasing use of primary and secondary cells has called for a book on batteries which will be of use not only to technical students, but to those

who are using such devices in their daily work. "Examples in Battery Engineering" contains just the right up-to-date information for both the average man and the engineer. In fact the title does not suggest the wealth of valuable information the book contains.

All laymen will appreciate the chapters on the methods of selecting and connecting batteries for various kinds of service, while students and designers will find the electrical, chemical and mathematical explanations of very great value. It contains numerous charts of operating conditions and diagrams of connections to illustrate the problems.

EXAMPLES IN MAGNETISM

Second edition. Price, postpaid, in flexible leather, $1.10.

To those who wish to make a study of magnetism, dealing with permanent magnets, "Examples in Magnetism," by Prof. F. E. Austin, will be found of much value. The book contains a large amount of carefully arranged data, with explanatory illustrations and diagrams. It is, however, a disappointment for those who want information about electro-magnets. It is to be hoped that the author will write a book giving the same careful attention to electro-magnets, as they are extensively used for a large variety of purposes.

MINUTES OF MEETINGS

September 11, 1917: Regular meeting called to order by President Herron at 8:10 p. m. Present, 105.

Minutes of May 8, 15, 22, 29, June 5 and 12 were approved.

Members were elected by the Executive Board on September 10, as follows:

Active: A. H. Ackerman, H. P. Cummings, W. C. Keys, J. N. Schweikert, and Harold Stott.

Junior: I. E. Waechter.

President Herron introduced Dr. C. S. Howe, who in turn introduced Dr. Ira N. Hollis, President of the American Society of Mechanical Engineers, Worcester, Mass., who gave a lecture on "Engineering and Co-operation". Messrs. A. H. Bates and C. S. Howe took part in the discussion.

Adjourned.

H. M. Wilson, Secretary.

September 18, 1917: Special meeting called to order by President Herron at 8:15 p. m. Present, 100.

President Herron introduced Capt. Irving L. Evans, in charge of the Government Training Schools on the Great Lakes, Cleveland, who gave a paper on "Our Merchant Marine, Present and Future". Discussion was participated in by Messrs. L. K. Baker, C. T. Harris, J. H. Herron, Ernest Hollings, F. S. Hunter, E. H. Loughridge, R. M. Morgan (Upson Nut Co.), W. J. Oettinger, K. H. Osborn and Prof. F. H. Vose.

Adjourned.

H. M. Wilson, Secretary.

September 25, 1917: Semi-monthly meeting called by President Herron at 8:15. Present, 110.

President Herron introduced H. G. Barnhurst, Chief Engineer, The Fuller Engineering Co., Allentown, Pa., who gave an illustrated lecture on "Pulverized Coal". Messrs. J. H. Herron, Willard Beahan, Willard Brown, J. B. Clapper, F. S. Curtis, W. M. Faber, W. B. Hanlon, Ed. Linders, John McGeorge, H. V. Schiefer, C. C. Smith and W. G. Stephan took part in the discussion.

Adjourned.

H. M. Wilson, Secretary.

October 2, 1917: Special meeting called to order by Vice President Thomas at 8:15 p. m. Present, 115.

Mr. Thomas introduced T. E. Austin, General Manager, Niles Crane Works, Philadelphia, Pa., who gave an illustrated paper on "Development of the Electric Traveling Crane". Discussion was participated in by Ernest Hollings and C. O. Palmer.

Adjourned.

H. M. Wilson, Secretary.

October 9, 1917: Regular meeting called to order by President Herron at 8:00 p. m. Present, 80 members and guests.

Reading of minutes of September 11, 18 and 25 and October 2 was dispensed with.

Members were elected by the Executive Board on October 8 as follows:

Active: G. W. Burrell, G. W. Elspass, H. H. Gronemeyer and L. J. Petre.

Junior: Harry Berlin.

Transfer—Associate to Active: C. L. Lohmeyer and G. O. Wright.

President Herron introduced Dr. H. C. Chapin as Chairman for the evening. Dr. Chapin introduced J. C. Gillette, who presented a paper on "Factory Fire Protection". Discussion was participated in by Messrs. H. C. Chapin, J. B. Clapper, George J. Cunningham (Philadelphia Rubber Co., Akron, Ohio), A. E. Derby, T. B. Hyde, Ed. Linders, M. F. Loomis, Adam Meyer, A. P. Regal (Philadelphia Rubber Co., Akron, Ohio), E. P. Roberts and J. E. Washburn.

Adjourned.

H. M. Wilson, Secretary.

October 16, 1917: Special meeting called to order at 8:15 p. m. by J. F. Oberlin. Present, 100 members and guests.

Mr. Oberlin introduced Herbert H. Dow, of the Dow Chemical Co., Midland, Michigan, who delivered a lecture on "Will American Manufacturers be Able to Compete with German Manufacturers After the War in Lines Where the Germans Have Heretofore Been Preeminent?" Messrs. C. T. Harris, H. E. Hackenberg, John McGeorge, W. R. Mott, A. W. Smith, J. E. Washburn and S. T. Wellman joined in the discussion.

Adjourned.

H. M. Wilson, Secretary.

October 23, 1917: Semi-monthly meeting called to order at 8:15 p. m. by President Herron. Present 75.

President Herron introduced P. M. Lincoln, Past President A. I. E. E., now with the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., who gave a lecture on the "Latest Developments in the Electric Transmission of Power". Messrs. G. F. Collister, J. H. Herron, J. C. Lincoln and others joined in the discussion.

Adjourned.

H. M. Wilson,
Secretary.

October 30, 1917: Special meeting called at 8:15 by W. J. Carter. Present, 90.

Mr. Carter introduced Robert Hoffmann, City Engineer, who gave an illustrated talk on "Cleveland's Sewerage

System". Messrs. A. F. Blaser, W. J. Carter, C. E. Drayer, M. F. Loomis, C. O. Palmer, J. A. Phelps, E. B. Thomas, G. E. Tower, I. E. Waechter and H. W. S. Wood joined in the discussion.

The following resolution was presented by the Sewer Committee and upon motion, duly seconded, was unanimously approved:

"The Sewer Committee, after careful consideration and study of the needs of extension and relief of Cleveland's sewer systems, and after listening to Mr. Robert Hoffmann's able exposition of the question, hereby endorses the three million dollar bond issue which is to be submitted to a vote on November 6."

Adjourned.

H. M. Wilson,
Secretary.

November 6, 1917: Special meeting called to order by President Herron at 8:15 p. m. Present, 100 members and guests.

Mr. Herron introduced Mr. Lindmueller as Chairman for the evening. Mr. Lindmueller introduced B. R. Tewkesbury, Industrial Department, the Cleveland Tractor Co., Cleveland, who gave a lecture on "The Crawler Type Tractor a Coming Factor Industrially", illustrated by moving pictures. Messrs. M. J. Bacon, W. L. Ely, J. C. Lincoln, John McGeorge, R. S. Mayer and others joined in the discussion.

Adjourned.

H. M. Wilson,
Secretary.

November 13, 1917:—Regular meeting called to order by Vice President E. B. Thomas at 8:00 p. m. Present, 85.

Reading of the minutes of October 9, 16, 23 and 30 and November 6 was dispensed with.

New members were elected by the Executive Board on November 12 as follows:

Active

A. F. Comstock,
A. E. Drissner,
W. E. Gross,
W. R. Mitchell,
O. R. Preisman,
H. W. Price.

Junior

Samuel Gertz.

Mr. Thomas introduced Fred H. Colvin, Associate Editor, American Machinist, New York, who presented a paper entitled "The Machine Shop and Modern Warfare" (illustrated). Messrs. E. E. Blundell, G. F. Collister, W. N. Crafts, Ed. Linders, M. F. Loomis, H. M. Lucas, John McGeorge, K. H. Osborn, C. O. Palmer, E. C. Peck, H. V. Schiefer, E. B. Thomas, I. D. Thomas, J. A. Williams and others joined in the discussion.

Adjourned.

H. M. Wilson,
Secretary.

November 20, 1917:—Special meeting called by A. F. Blaser at 8:15 p. m. Present, 60.

Mr. Blaser introduced Virgil D. Allen, Consulting Engineer, Cleveland, who presented a paper on the subject of "Limiting the Height of Buildings". A discussion followed by Messrs. L. K. Baker, A. F. Blaser, R. B. Clapp, Silas Hunter (local U. S. Government Steamboat Inspector), Ed. Linders, K. H. Osborn, C. O. Palmer, O. F. Palmer, H. H. Smith, G. E. Tower and J. E. Washburn.

Adjourned.

H. M. Wilson,
Secretary.

November 27, 1917:—Semi-monthly meeting called to order at 8:20 by W. P. Blair. Present, 65.

Mr. Blair introduced W. A. Alsdorf, Secretary, Ohio Good Roads Federation, Columbus, Ohio, who presented a paper on "The Relationship of the Highway to Freight Transportation". Messrs. W. P. Blair, Ed. Linders, D. Moomaw and B. H. Simpson joined in the discussion.

Adjourned.

H. M. Wilson,
Secretary.

December 4, 1917:—Special meeting called to order by President Herron at 8:15 p. m. Present, 140.

President Herron introduced H. H. Dyar, who gave a paper on "Oxy-Acetylene Welding and Cutting," with demonstrations of this process. Messrs. A. F. Blaser, W. L. Ely, J. C. Lincoln, Ed. Linders, John McGeorge, R. M. Morgan, W. J. Oettinger, H. V Schiefer, R. E. Stark, Armen Tashjian and I. E. Waechter joined in the discussion.

Adjourned.

H. M. Wilson,
Secretary.

December 11, 1917:—Regular meeting called to order by President Herron at 8:05 p. m. Present, 95.

Reading of the minutes of November 13, 20 and 27 and December 4 was dispensed with.

President Herron announced the names of men elected at the Board Meeting, December 10, as follows:

Active

H. M. Hunter,
I. F. Niles,
D. H. Scott,
B. H. Simpson,
H. A. Stevenson,
W. H. Watkins.

Associate

R. C. Kinley.

Corresponding

G. M. Hunting.

Junior

A. V. Borklund,
A. A. Hausmann,
J. F. McFadden.

The President introduced R. E. Kinkead, who gave a paper on "Electric Arc Welding", followed by demonstration.

Messrs. W. H. Brainard, W. H. Burrage, J. C. Gillette, J. H. Hall, E. H. Loughridge, R. S. Mayer, W. J. Oettinger, A. W. Ray, C. C. Smith and F. W. Thomas and others joined in the discussion.

Adjourned. H. M. Wilson,
Secretary.

December 18, 1917:—Special meeting called to order by President Herron at 8:15 p. m. Present, 95.

President Herron introduced F. D. Richards as Chairman for the evening. The subject for consideration was the Clark Avenue Bridge, and Mr. Richards introduced James Ritchie, Howard Brocklebank, E. J. Newton, F. F. Buck and A. B. Cook, who spoke respectively on the foundations, the design, the fabrication, the erection and the construction of this bridge.

Mr. Robert Hoffmann gave a short discussion.

Adjourned. H. M. Wilson,
Secretary.

JOURNAL OF
The Cleveland Engineering Society

The Relation of Highways to Freight Transportation

By W. A. Alsdorf*

Paper Presented Nov. 27, 1917.

Index No. 625.7

The most vital problem of the great world war is that of transportation. For months the greatest menace of Allied success, the gaunt spectre that has haunted the counsel chambers of the leaders of the Allied cause, has been the submarine; and this because the sub-sea craft threatened the lines of transportation that must be kept open if the Allies were to be fed, clothed and provisioned, and if the men and the national wealth of America were to be thrown into the scale in a way that would count. The break-down in the spirit and morale of the Russian people was preceded by an almost complete paralysis of that country's transportation. Much of Germany's apparent success has been due to the fact that she has been fighting from the inside of a circle with greatly shortened lines of communication and a resultant lessening of her problems of transportation. It is isolation and lack of transportation facilities that renders impotent the hundreds of thousands of trained soldiers of the Japanese Empire. The Allies have a vast preponderance of men, money and national resources; and a solution of their transportation problems which will permit them to exert their strength along the western front will enable the armies of Haig, Petain and Pershing to drive the Germans across the Rhine and end forever the Kaiser's dream of world conquest.

But the transportation problems of the war, so far as the Allies are concerned, are not all external; they do not all relate to keeping open the paths across the sea and providing ships and ships and still more ships. Each Allied country has its own internal transportation problem, and of these problems that of America is not the least. Our country like its Capital City is noted for its magnificent distances, and its transportation problems present many aspects that are absent in a country like England, where every haul is, comparatively speaking, a short haul.

Whatever may be our problems, however, we are coming to realize more and more that efficiency in transportation, both across the seas and within our own borders, is and will be the measure of our success in winning the war. Today the lack of ships is the greatest handicap to our plans for defeating Germany. For tomorrow a dual danger is appearing upon the horizon, the breaking down of our railway facilities and our lack of preparation in the past, now so plainly perceived, to supplement our railroads by the construction of a complete and usable system of highways. Either the paralysis of railway transportation or our failure before another winter to remedy our situation with respect to highways will constitute a broken link in the chain of national effort for victory.

War conditions have so increased the transportation needs of the Federal Government that the available railroad transportation facilities are insufficient to meet the present combined demand of the Government and private enter-

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prise. Inadequate transportation facilities have already become a strong limiting factor in general business, thereby decreasing both the earning power and industrial efficiency of our citizenship. The railroads of the country admit their inability to cope with the dual demands being made upon them, and a further decrease of transportation service may bring not only suffering upon the people, but also a possible catastrophe to the nation by reason of its helplessness to transport those things absolutely necesary for use upon the farm, in the mill, the factory, the store and the home.

An abnormal transportation problem confronts the country. In normal times about one billion three hundred and twenty million tons of freight are handled annually, yielding about two billion dollars in gross revenue. Last year this amount was increased about 41 per cent and this year about 11.9 per cent will be added to last year's figures. Our domestic trade has increased about 50 per cent and our foreign trade over 100 per cent. In addition to this an unprecedented amount of government supplies is being moved to and from tide water, and in many instances handled half a dozen times from one plant to another in the process of manufacturing and finishing. Thus the reason of abnormal railroad freight congestion is made apparent.

The President says: "The course of trade shall be as unhampered as it is possible to make it." To what other method of transportation can we turn in the hour of our emergency to maintain trade but to the public highways. They are the only great agency we can use to supplement the transportation facilities of the railroads. Private enterprise, so essential to a healthy business condition and to the successful prosecution of the war, may within the next year be compelled to depend largely upon transportation over the public highways for its very existence. To this already breaking strain placed upon our railroads by the industrial and commercial demands is added another of even greater importance. President Wilson has said that "Upon the farms of the country in a large measure rests the fate of the war and the fate of the nation. May the nation not count upon them to omit no step that will bring about the most effectual co-operation in the sale and distribution of their products." The world faces a food shortage. It faces unprecedented prices for foodstuffs. The American farmer has been appealed to from every source to increase his crops that the world may be supplied with food and that the price may be kept down. Yet, not a bushel of grain nor a pound of meat is grown in this country that does not at some time in its journey, from the point of production to the point of ultimate consumption, pass over some of our American highways on its way to the railroads. Thus we see that the business of the nation is depending largely upon a single unit of transportation now bending almost to a breaking point, and the public highways as the only auxiliary means of transportation have suddenly by reason of war conditions grown from a position of economic usefulness only, until they have become a vital war necessity and the very foundation for the superstructure of our national prosperity, stability and efficiency.

As we were unprepared in shipping and in railway requirements, in munitions and war supplies, so were we also unprepared in the physical conditions of our highways for this sudden transformation of trade. But as we have met the other and greater problems so can we meet and solve this one.

Today the call is for our brains as well as our blood for our country. American business men have answered their country's call in a manner never known in the past. A few years ago it would have been impossible to gather together at Washington the greatest business minds in the country for the purpose of running the affairs

of the nation, yet today we have the services of our best railway executives, our best steel men, our best engineers, our best economists, all working hard and making history. They are putting their heads together and evolving methods for increased efficiency and getting things done that are astounding. All over the country business men have turned their thoughts in a common direction to do those things necessary to prosecute the war successfully and to keep the essential industries of the nation going at top speed. This is the real job of those who stay at home and thus it seems peculiarly expedient to present to you today this subject, and ask for it your most careful consideration.

A partial solution of the transportation problems is indicated in a bulletin issued by a Committee of the National Council of Defense containing the following statement: "The agricultural, commercial and industrial world must turn to the mutual use of motor trucks to relieve freight congestion, and apply the same high standards of organizations, efficiency and development to motor truck service as now characterizes modern industrial plants." The usefulness and pertinency of this suggestion may be the better realized when we stop to think that fully 60 per cent of the present freight congestion at terminals is due to small merchandise passing from the manufacturers to the jobbers and thence to the retailers, involving in nearly all instances a haulage within the capabilities of the motor truck.

Thoroughly organized freight and express service might be adopted by those communities that are suffering from freight congestion, utilizing the motor truck for the collection of raw materials and the delivery of finished products within a radius of 100 to 150 miles. In fact this is the immediate purpose to which the recently appointed Highways Transport Committee of the National Council of Defense are giving their attention. The motor truck is not today a vehicle of the cities and towns, but its use is as general as the distribution of mail; its ramification as broad as those of the rural telephone, and its use takes in every road, improved or otherwise, in the country. Intercity haulage of commodities is not an experiment. The practicability has been established in practice and when the schedule provides for the truck carrying a capacity load on its return trip such haulage has proven a profitable investment. Co-ordination of manufacturers in utilizing their trucks to haul in both directions is necessary for economy and profit. The collection and distribution of agricultural products are also necessary factors in the problem. The establishment of a mutual freight and express service will not be confined alone to manufacturers, for the plan is equally practicable for community uses and to supply cities and towns dependent upon outside sources for food supplies. The use of fleets of motor trucks by merchants and municipal authorities will facilitate the distribution of supplies to sections unable to obtain commodities through regular channels. Such a service will satisfactorily bridge the gap between the producer and consumer and encourage the development of home markets for home products. In many parts of our own and other states, motor trucks have been used to market farm products direct. It has been found that such shipments are more rapid than railway. Freight congestion and shortage of cars not only this year but in the past have caused tremendous waste at points of production as well as at terminals. To reach close-by markets the motor truck actually beats the railroads, both as to cost and time, thus serving the producer better than has ever been done before. Very recently the Federal postal authorities have taken up the question of establishing a heavy parcel post service between Columbus and Zanesville, a distance of 57 miles

over a highly improved road, with a view of finding out a basis of cost upon such deliveries. This truck service supplemented by the present large volume of vehicular traffic would enable the entire country to become self-supporting and would make possible the utilization of a very large part of our railway facilities by the Federal Government, if our public highways were in a usable condition.

Out of some two million miles of roads, or rights of way, in this country we have today, at the most optimistic estimate, some 200,000 miles which have received any attention or improvement of any character, and to the best of my knowledge not over 40,000 miles of roads have been actually constructed with some degree of permanency and maintained in such a fashion that they could be used as an auxiliary transportation system. And, even this available road mileage is limited in its usefulness by the fact that it has been constructed under no central directing intelligence, that it is the result of local endeavors at widely separated points and does not in any degree link up to form what can be referred to as a "Road System"—roads which lead from some place to some place.

The President in his war message to the American people said: "This is our opportunity to demonstrate the efficiency of a great democracy and we shall not fall short of it!"

To which we might observe, that the efficiency of this democracy, the efficiency of any political unit, depends largely upon the degree of national unity of purpose and the degree of centralized directing authority exercised over great national enterprises. The highest efficiency in a factory cannot be reached under a plan which contemplates each man going ahead upon his own initiative, undertaking that which pleases him best, and doing it in a way which suits his individual taste. Neither can the greatest efficiency be reached in road building under a plan which makes the ultimate completion of the whole dependent upon each minor local unit doing its share in its own way with its own limited ability and funds and from its own standpoint.

It would, therefore, appear that present methods for improvement of public highways are antiquated and not suited for present needs, and that by reason of the serious conditions affecting transportation facilities today and the imminent dangers to the nation's prosperity and safety, it is imperative to immediately readjust the methods of highway improvement to meet the requirements of the nation. To this end Congress should be urged to declare road building a war necessity and to take steps to formulate a definite plan, that will nationalize road building throughout the country. Such a plan should co-ordinate the road building activities of every unit of government. The needs of the Federal Government might necessitate a designation of certain main roads that are of military or strategic importance, to be national roads. It should provide that the links and gaps upon these roads should be improved at once with all the resources and funds available for that purpose by the Federal Government. If needed it should provide that bridges and culverts be strengthened to pass heavy artillery or other exceptional loads. It might further designate as a second class those roads of primary importance to the industrial centers of the various states. The Federal Government and state authority should alone be responsible for their improvement, which should not in any way be hampered by the ability or desire of the lesser units of government.

The third class for improvement would be those roads connecting up our county seat towns upon which largely rests the burden of handling the agricultural products of the country. While these should be improved very largely at local expense, yet it would seem that the great need of the present would justify both the

Federal and State Governments sharing a part of the investment.

A fourth class would be those roads of local significance whose improvement should be guided in a manner to be supplementary to the other system. Such a centralizing plan would necessarily mean the changing of the laws of many states of the Union, as well as Federal law affecting it. Present limitations for issuing bonds and making levies would have to be changed. Transportation of road building materials would no doubt be guided by certain priority rulings of the Federal authorities that would be in line with the improvement of the various classes determined to receive it. The financing of the various projects would no doubt receive consideration by the Federal Reserve Bank System and its member banks throughout the country. The labor problem would receive consideration and no doubt its solution could be brought about through co-operative State and Federal authority. In fact the Federal Government would be the guiding hand in all steps necessary to bring speedily to a state of usefulness this great highway transportation system of the nation.

By some such systematic central plan we would be able to bring about quickly a wonderful transformation in the conditions of our public highways, thus enabling them to be, what they rightfully should be, the second greatest public utility of our country. It would then be possible to relieve the congestion of the railroads, keep the mills and factories busy, collect and distribute the foodstuffs, and give a stability and mobility to the resources of America.

The relation of the highways to freight transportation will then be like that of America to her Allies, the basis of their strength and power, as well as their salvation in the hour of their peril. Build the public roads with even a small part of the gigantic energy that we are using to build and equip our shipping, or furnish supplies to our Allies, and you will equip America with a power to unfold her resources immeasurably in war, and give her an agency for expansion and trade when peace is restored, far above that of armies or navies or the mighty equipment of war.

DISCUSSION

W. P. Blair.—Perhaps they would like to know the amount of money that Ohio is expending for road improvement.

W. A. Alsdorf.—The appropriation in the last General Assembly from the famous automobile funds was $4,-640,000, to be expended in the two years July, 1917, to July, 1919—the annual expenditure of the state aid funds to be about $2,250,000 a year in addition to that. The state aid fund is divided into two funds, 75 per cent of the $2,250,000 going to what is known as the inter-county highway fund, and 25 per cent of it to the main-market fund. Those funds are supplemented by about $550,000 of Federal funds available this year, made up of $186,000 of last year and about $380,000 of this year funds. Next year we will also have some $550,000 from the Federal Government. All of these main funds are the funds that are available by the State of Ohio to be expended under state supervision, and do not take into consideration about $5,000,000 that is expended by the counties, and an additional $2,000,000 that is expended annually by the townships of the state.

W. P. Blair.—How much do we get from the national government?

W. A. Alsdorf.—About $550,000 this year, and the same next.

B. H. Simpson.—Is it possible under the Ohio laws to secure state aid and federal aid on the same project?

W. A. Alsdorf.—Yes, it is. It is entirely at the discretion of the State Highway Advisory Board, and the State Highway Commissioner, as to whether they want to apply the main-

market fund—or to recommend to the Federal Government that the federal funds be expended upon any particular project, that is a part of the accepted designated Federal Aid System of the state.

B. H. Simpson.—It is possible, then, to have state aid and federal aid on the same road?

W. A. Alsdorf.—Yes, but the federal projects take in only about 1000 or 1200 miles of roads, merely a part of the main-market road system in the state, while the full main-market system upon which state funds can be used is about 2600 miles. Ohio has improved about 2000 miles within the last three years, or four years at the most. There are now under state maintenance about 2600 miles. As the counties bring their roads up to the standards of the state, they have the right, if they so desire, to turn those roads over to the state for maintenance, thus relieving the counties of their share in the maintaining of the system. But we have depended almost entirely upon the local units in determining the place where the expenditure has been made.

We have got to get away from it in this hour of need when we must improve our highways up to a good point of usefulness to be used by motor trucks and other vehicles. It is useless for us to depend upon the co-operation of the smaller units, that is, especially the townships and the counties. Of course, this county is an exception; so are the other four or five, or you might say even ten counties in the state about which that remark would not apply. But there are 75 counties in the state that proceed on the old method of bringing the township or the abutting property into the proposition, and there you have the problem always of how much of the improvement the property owners are going to pay, how much the township and how much the county and the state. Now you can readily see there are four elements in there that complicate the whole situation, and if we are going to improve through roads for the use of the Federal Government, why we have simply got to get away from those entanglements of the smaller units of the Government as well as the abutting property owner.

Dalton Moomaw.—I would like to ask Senator Alsdorf if there is any progress being made toward the lifting of priority order No. 2?

W. A. Alsdorf.—There is no progress being made towards that for this reason, that the order was an emergency order. It was brought about by the condition of the coal trade, in which it was a choice between furnishing coal to public utilities, schools and homes in certain quantities, or continuing road building; they had deferred its issuance to the very last moment, and they seemed to be obliged finally to issue the order to protect the citizens and the schools and the homes against possible freezing this winter. It is regarded as an emergency order that will be lifted the first of January.

Dalton Moomaw.—It looks to me as though we ought to have some statement of the problem along that line, because it is very evident that the Government is taking a considerable interest in some of these through routes, and it will be impossible to let any contracts for the improvement of these highways unless the contractor can see his way clear to get materials to build them. So the letting of contracts will have to be deferred until that question is finally settled.

W. A. Alsdorf.—I think you are right. In fact, all of us, you might say, are in very much of a quandary in regard to road building all over the country. It looks to some of us as if it is necessary to do the very thing you mentioned, and that is to urge a definite federal policy in regard to road and street improvement. Now, as I have suggested here in the paper, perhaps this federal policy can, and

it should, determine certain routes that we will say are of national concern, that have strategic value. They are all the time telling us here to improve the Lincoln Highway or the old National Road, or something like that, so as to give us connection from Indianapolis, Dayton, Chicago, etc. Now, there are other routes that are a federal necessity to the industrial centers of the states of Ohio, Illinois, Indiana and Pennsylvania. If the United States Government is going to guide road improvements, it will mean, first, the designation of the projects, whether it be federal or state or local, then there will be an issuing of priority orders that will govern transportation or road building materials for these projects; it will mean the permission to carriers to furnish coal and other equipment to the plants that furnish the road building materials for these projects, and it will even go further, I believe, and carry to the federal banking system the idea of taking care of the bonds to be issued for the various projects. So it looks to me as if it is absolutely necessary for the Federal Government to take this thing up and nationalize it as they are doing every other business.

DALTON MOOMAW.—It was only today that there were three army officers in the office looking up data on a route through the county, and they had in mind the moving of a fleet of trucks from somewhere in Michigan, I presume, to somewhere in the East. I do not know just how many they had in mind, but these would be loaded anywhere from five to perhaps twelve or fifteen tons gross load. I think it would be safe to say that while we have perhaps the most thoroughly improved system of roads of any section in the state, that if this kind of traffic is of very long duration, quite a number of miles of these roads would be impassible before the opening of next summer, and they need a great deal of attention to keep them in shape for the continuous use under that traffic. Whether that will require railroad transportation for materials or not I cannot say.

W. A. ALSDORF.—It will. At the present time the department in Washington, especially the war department, have discovered through their various legal lights that they have no money to spend for the improvement of these roads, that their right of expending money is limited entirely to the cantonments, that there are no funds available today by the Federal Government in any department that they can spend on public roads except what is now provided by law under the Bankhead-Shackleford Law, and that, of course, is designated as federal aid to the states; so it seems to me Congress must take this thing up and appropriate a fund available for maintenance of these roads that you speak of, otherwise traffic will tear them all to pieces this winter. Now, they say there are about 17,000 trucks to go east between now and the first of May. I do not know when or how they will get them through, but they will certainly damage some of these roads.

W. P. BLAIR.—Upon this subject we read some very curious things in the papers, and some very remarkable facts come to our ears. We do know that a few days ago the War Department requested an examination of roads from Chicago, Toledo and Detroit by way of Cleveland to the seaboard, over which there might be moved from 17,000 to 40,000 trucks for transportation to France. We see also that Secretary of War Baker telegraphed Governor Sleeper of Michigan to put the highway in condition at once between Toledo and Detroit so that trucks might be moved over it, and this for the purpose of relieving the railroads from that much tonnage.

Doubtless you are all acquainted with Priority Order No. 2, and in the face of that it was shown that 26,000 carloads of coal were congested on the railroads in the state of Ohio awaiting boat transportation to the

north, with no boats in which to load the coal.

We read Mr. Hoover's advice that our housewives are to wash potatoes and cook them in their jackets to economize, by not peeling them too deep; and then we read in another paper that 75 miles out from Cleveland here there are over 10,000 bushels of potatoes about to rot because the roads are so bad you cannot bring them into Cleveland. We read in the paper that they are feeding 10,000 bushels of wheat a day to hogs in some counties in Oklahoma because the bridges are so imperfect that they cannot get the hogs out or the corn in, so they feed them wheat. And we found that in the examination of routes from this part of the country to the seaboard (this was discovered by the Goodyear Rubber Company which now operates a fleet of five trucks from Akron to Boston, and they say that they are making better and more economical movement of tonnage from Akron to Boston by trucks than they could by rail or express) that on a careful examination heavy trucks could not go over the northern route through New York because the state of New York failed to utilize engineering service in planning their highway bridges and they have bridges that would not hold up the load that might be put upon an ordinary five-ton truck.

Ed. Linders.—You said that in certain cases the state would take over the maintenance of roads constructed by counties or townships. Does the state require that these roads be built under certain definite specifications relative to width of road, and so on, or will they take any road it is desired to turn over as long as it is an improved road?

W. A. Alsdorf.—They can take over roads that are a part of our inter-county system. The main-market and inter-county highway system was established in 1911 and perfected and filed with the Governor and the Secretary of State in 1913. It comprises about 10,000 miles of roads in the state of Ohio, connecting county seat towns with county seat towns, and there is an average of perhaps 150 to 200 miles of inter-county roads in each county. They are the main roads in the county. Now, the state will take over any part of this system in a county that has been improved locally, that is, up to a standard that is prescribed by the state. They will not take over a road that is ten or twelve feet wide and maintain it, but in a case of that kind, if the county wants to turn over the mileage, they take three or four thousand dollars from the maintenance funds of the state and put that with a similar amount of the county funds, and by that joint state-aid fund bring the road to a certain degree of excellence, or a certain standard, generally about sixteen feet wide, with a fair surface, a surface that will answer for the character of the traffic upon it. Then by resolution passed by the Local Board of County Commissioners requesting the state so to do, saying that the road has been improved up to the standard required by the state, it is accepted and taken over.

Dalton Moomaw.—The improvements on the inter-county highways in this county are practically all brick. A few of them are macadam. The State Highway Department does not require that they be improved by brick in order to be taken over and maintained by the state. However, some of ours have been a narrow pavement widened with a strip of macadam. The majority of the improvements on our inter-county highways have been made by the county alone, and not all of them have yet been taken over by the state, simply because it was such a big job that we could not get the information right off the bat to file in the State Highway Department. However, the State Highway Department has been assuming the maintenance of quite a number of these roads without having formally taken them over.

Regulation of Height of Buildings

By V. D. Allen*

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Index No. 725

A serious study of the further regulation of the height of buildings is a timely subject for Cleveland. Our city is rapidly approaching a world metropolis in size, and unless intelligent regulation is applied, we will soon be confronted with all the municipal problems coincident to such cities.

Every form of building control is in some measure, associated with city planning, and the regulation of the height of buildings is almost another name for that form of civic betterment.

Cleveland has enjoyed the protecting influence of height limiting ordinances of a mild form for many years and, therefore, it seems appropriate that I trace briefly the history of these regulations.

We find the first germ of height regulation in an act of the General Assembly of Ohio, passed March, 1836, to incorporate the city of Cleveland, a constituted charter of the city for many years. In Section 7 thereof we find this:

"That for the purpose of guarding against calamities of fire, the City Council may, from time to time, by ordinance, designate such portions and parts of the city as they shall deem proper within which no building of wood shall be erected, and may *regulate* and direct the erection of buildings within such portions and parts, the *size,* materials, etc."

I take it that the word "size" was used by the framers of this bill as being broad and inclusive enough to comprehend the height, as well as the other dimensions of a building, but the need of height regulations did not manifest itself to the city fathers of that time, and they evidently attached little significance to the possible meaning of the word "size", for in May of that year the Council passed "An Ordinance for the Prevention of Fires", consisting of 15 sections, and the only place the word "height" appears is in Section 14, which reads in part:

"Every dwelling house or other building more than one story in height, within the city, shall have a scuttle through the roof, and a convenient stairway or ladder leading to same."

By no stretch of our imagination can we conceive this to be a height limit regulation, although as I have suggested, they had power under the charter then existing, to so regulate.

The next appearance of the idea comes from the legislature again which on May 3, 1852, passed an act providing for the organization of cities and villages, section 21 of which refers to the regulation of buildings, and reads in part:

"They, the Council, shall have power to provide for the *regular* building of houses; to make regulations for the purpose of guarding against danger from accident by fires; and on petition of the owners of not less than two-thirds of the ground included in any square, to prohibit the erection in any such square of any building more than ten feet high, unless the outer walls are made of brick, etc."

It is interesting to note that the words "Regular building of Houses" occur in the first paragraph, which would seem to indicate that some one was having a vision of city planning as early as 1852.

The City Council, acting under this power, passed an ordinance May 10, 1854, prescribing a fire limit, covering

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the block bounded by Superior, Ontario, Water and St. Clair streets, and this may properly be designated as the beginning of the regulation of height of buildings in Cleveland in any manner or degree. However, in this case the only limitation depends on the kind of construction and there is no actual limit of height set, provided the material used in constructing the building is of a specified kind.

In the legislation so far referred to, the only reason for limiting the height of buildings was that of fire protection, and in no case is a maximum height limit set.

There was no further legislation until April 16, 1888, when the legislature of Ohio passed an act, entitled "An act to Regulate the Construction of Buildings Within Any City of the First and Second Grade, and to Provide for the Appointment of an Inspector of Buildings". This act consisted of 53 sections and automatically became the building code of Cleveland, and in May of that year an Inspector of Buildings was appointed. This is the beginning of our building department, as prior to that time the inspection of buildings had been a function of the fire department.

I cannot find that this act regulated the height of buildings, only in what might be termed a left handed manner, that is, there were two tables in the act covering the thickness and height of walls, and the limit of heights set by these tables was 100 feet. I understand that this was construed to be the limit of height of any building. As structural steel at that time was in its infancy, I consider this more of a structural than a civic regulation of building heights.

Again in October, 1902, the legislature passed an act called "The Municipal Code Act". This in effect, repealed all the building regulations that Cleveland then had, and as a result a commission was appointed, who prepared what is known as the "Eisenman Code", which was adopted by Council in June and October of 1904. Some slight changes followed, and in 1907 the ordinances of the city were codified and thereafter this code was known as part of the revised ordinances of 1907. In this code appears the present height limits, and this regulation of height is really the first that Cleveland has had which is based on any theory except engineering limitations or fire prevention.

All building regulations are based on the police power, which in the past has been interpreted too narrowly by the courts for the community, and by the same sign too broadly for the benefit of the individual whose building it was proposed to control.

If the police power, as has been generally construed in the past, can deal only with structural safety and the fire hazard, then there is little chance to limit the height of buildings, for as an engineering problem we can build to that height which will require all the first floor area to be used for columns, and the fire hazard can be reduced almost to zero by the use of sprinklers and strictly fireproof materials.

From a financial viewpoint, they can be built to that height where construction and operating costs accelerate to such a degree that they absorb the advantages of the intensive use of the land. Manifestly, if the height of buildings is to be limited, then it arises from other reasons for communal betterment than those which the police power has in the past been construed to cover and apply to. We have had sufficient experience with high buildings in American cities to indicate in no uncertain manner the evils that follow in their wake. In 1913, the city of New York, realizing their condition in this respect, appointed a commission to investigate. This investigation was made in a very thorough manner, and I would recommend to anyone interested in this

question a careful reading of their report.

I will review and comment briefly on a number of the evils which this report points out as resulting from unlimited building heights. Probably the greatest is that of street congestion. The high building houses thousands of people, nearly all of whom enter and leave the building about the same time daily. To come from their homes, which are scattered in all directions, they require street cars, automobiles or other vehicles, which as they converge to one point, create serious congestion on roadways, as well as sidewalks. For example, a building housing 1000 people, which would be a small building, calls for the use of 12 or 15 street cars to carry the occupants, and these cars would fill the car tracks for an ordinary city block. It must be remembered that for each 1000 fixed users of a building, there must be several hundred transients to be reckoned with. If one large building has so pronounced an effect upon street congestion, what must be the result when we reach the point where we have entire city blocks so improved.

A traffic count in New York shows us the startling effect of congestion. On Fifth avenue at Forty-second street, from 8:30 a. m. to 6:30 p. m., a period of ten hours, during which time there passed 18,800 vehicles and 137,780 pedestrians, and for the same hours counts taken at ten points on Fifth avenue, ranging from Fourteenth street to Fifty-ninth street inclusive, showed an average of 14,096 vehicles and 82,506 pedestrians. We think of a city having a population of 137,000 as a real town, yet here we have a condition where all the people of a large city pass one point on one street in a period of ten hours, and a mass of vehicles, which allowing 20 feet to each one, would make a procession 71 miles long, also passing at the same time. Such vast numbers are more than we can fully realize, and should be of themselves sufficient comment.

Manifestly, with such crowds in the street, there must be serious congestion within the buildings themselves, some of which house as many as 3500 people, to which, if we add the transients, we can safely estimate that more than 4000 persons are in the building at any moment for a number of hours each day. Four times daily these persons must enter or leave the building in a comparatively short space of time, which must create an elevator congestion that is both serious and dangerous.

Let us consider some of the results of the street and building congestion:

Obviously, the wear on the street pavement must be very severe, and the cost of maintaining good streets under such a concentrated heavy traffic is of necessity high. The problem of street building, to stand up under heavy traffic in the cities is a serious one as every engineer knows. There must also be present a large amount of dirt, dust and other debris, which when blown by the wind is injurious to goods, buildings, furnishings and health. Estimates have been made from time to time of the property loss due to smoke and dirt in cities, and the most conservative of these estimates are very large amounts. The noise and confusion resulting from so vast a throng of moving people and vehicles is very great, and according to the medical authorities, produces a noticeably injurious effect on the health of those who are constantly a part of it.

There are many problems of transportation, both of humans and produce which are created by this congestion.

The collecting and concentrating of such great numbers of people into a small area and distributing them to their homes again daily, brings street, street car, terminals, shelter and other problems of great magnitude and difficulty. The raw material which they use, and the finished product which is produced from them, together with

the appliances and power used in the processes, and the feeding of those so engaged, creates problems of transportation and handling of goods, which are large and complicated.

Besides the congestion above the surface, there is a serious congestion beneath the surface of the streets, for the presence of many large buildings requires an increase in the sewers, water lines and conduits, and other ground service, as well as the constant tearing up of the already overcrowded street surfaces to renew or repair the underground work. Investigation shows that as congestion of traffic on streets increases, the number of accidents increase in about the same, or perhaps in an accelerating ratio, and of necessity the number of men employed as traffic officers must be increased, which is another cost that the city as a whole must pay that we may have high buildings.

Another effect of congestion is the problem of the feeding of this vast throng of people at the noon hour. There can be no doubt that this shows itself in lower health since thousands must eat in a hurry, food which is poorly cooked, and under conditions which are not congenial, and after their meal there is no chance for the relaxation or the recreation which they need.

So we might go on enumerating evils which grow out of street congestion, but as there are other phases of the high building problem which should be considered, let us pass on.

The effect of such buildings on the sunlight and air are probably next in importance to that of traffic congestion. The loss of sunlight at the street surface and to the surrounding buildings is in itself an evil of sufficient magnitude to condemn high buildings. I shall give you some figures developed by the engineers of the New York commission. They apply with equal force to Cleveland, since we are in about the same latitude as New York. They base their figures on the shortest day of the year, which is December 21 at noon, and find that the Adams Express Company building, which is 424 feet high, casts a shadow 875 feet long. The Equitable building, which is 493 feet long, casts a shadow 1018 feet long. The Singer tower, which is 546 feet, casts a shadow 1127 feet long, and the Woolworth tower, which is 791 feet high, casts a shadow 1635 feet long.

The Equitable building shadow covers an area of 7.95 acres, while the area of the building itself is but 1.14 acres. From this, it is manifest that this building robs all the surrounding buildings, except those constructed to the south of it, of a large amount of sunlight.

A north and south street in New York with buildings on one side only, receives at the street level on Dec. 21 at noon, four hours and thirty-five minutes of direct sunlight, whereas with buildings on both sides of the street equal in height to one-half the width of the street, the direct light at the street level is reduced to two hours and thirty-six minutes. If the high buildings are equal to the width of the street, there is light for but one hour and ten minutes; if their height is twice the width of the street there is light for one hour; two and one-half times the width of the street reduces the light to 47 minutes, and six times the width of the street reduces the light to 27 minutes.

Cutting off the sunlight from the street produces a damp and dreary effect, alike depressing and unsanitary, but while the loss of sunlight at the street surface is bad, the effect of cutting off sunlight on the occupants of the buildings is a more serious evil.

Under the same condition, that is at noon Dec. 21, at a north and south street, and having buildings on both sides of the street, one and thirty-five hundr[illegible]hs times the width of the street in height, it is claimed that all the windows get some direct sunlight, but if the buildings were increased to one and one-half times the width of the street in height, then

but 90 per cent of the windows will get direct sunlight, and as the height of the buildings are increased the amount of windows getting direct sunlight decreases rapidly until when we have buildings six times the width of the street in height, the percentage of windows which receive direct light is reduced to 22½.

Not only this, but under the same conditions a window which has a building on the opposite side of the street one time the width of the street above it, has direct sunlight entering it but 12 per cent of the time that the light would enter an unobstructed window. This loss of sunlight reacts unfavorably on the general health of the occupants of the building and since it is necessary to use artificial light all the time, the strain on the eyes of the persons in such buildings is severe and results in many forms of human ills, which, of course, decreases the efficiency of these persons as producers.

There is also the cost and maintenance of light and the inferior product resulting to be added to the economic wastes chargeable to high buildings. The air in the streets, courts and yards which are flanked by high buildings into which but little direct sunlight can shine is, according to the best authorities, injurious to health, since the sun's rays have the power of purifying the air as nothing else can.

It is common knowledge that men who are continually confined in dark prisons, grow anaemic, and even die, although otherwise well cared for, and it is also a well known fact that Arctic explorers who have experienced the long winter night of the polar regions grow haggard, morose and quite abnormal under this condition, all of which symptoms disappear quickly with the return of the sun. Can we expect to have a strong and progressive race of people when thousands of them are compelled to leave their homes before the sun is fairly up, take a long ride in a street car, worse still, perhaps, through a subway, and work all day in a room where the sun never shines, a room ventilated by courts where the sun shines only for a few minutes each day, and where the air is further charged with dust and smoke, returning at the end of the day's work by repeating the ride on the street car and finally reaching home about the time the sun sets?

The answer is found in the experience of the British war office when recruiting for the Boer War. In the city of Manchester 72 per cent of the men examined were rejected on account of physical disability, and it was the opinion of the authorities who investigated the subject at that time that this condition was due to the abnormal living and working conditions under which these men were placed.

Thus far I have treated high commercial buildings only. Now, just a word on high tenements—the modern cliff dwelling. Here we have another class of evils due to abnormal domestic conditions, and when those who toil in the high commercial building, as is frequently the case, are compelled to live in high tenements, it seems to me we have created a condition of life which is doubly destructive to the progress of the human race. Volumes have been and many more could be written portraying the evil influences of the tenement on the social life of the modern city, but I will not take your time more than to thus briefly bring it to your attention.

Students of high buildings have placed much emphasis on the fire hazard created by these buildings, and while it is an important feature and should be considered, it is in my judgment not so important an objection to them as has generally been contended. It is true that the fire departments cannot reach a fire which is more than 80 or 90 feet above the street except by the use of a stand pipe, but the danger from fires in

office buildings is very small and can be almost eliminated by the use of fireproof material in their construction and the proper protection of wall and vertical openings by fireproof windows and doors.

In high buildings where large quantities of combustible goods are kept, the fire hazard is a real factor, but even here the danger can be materially reduced by the use of sprinkler systems in addition to the safeguards already mentioned. When we come to consider high tenements and loft buildings where the panic and life hazard must be added to the fire hazard, it becomes a real and serious problem. It is important to notice, however, that the presence of high buildings makes it necessary for large and extensive increases in the fire department equipment, and the installation of additional water lines and service, all of which are costs that the community at large must pay in order that a few may own high buildings and reap such benefits as may arise therefrom.

The financial side of this question deserves a word. The testimony given before the New York commission demonstrated that the skyscraper was not a good paying investment. While it is true that one such building standing alone will pay, since it can get its light and air from the surrounding property, yet when other such buildings are built around it and it has lost this advantage, then its renting value decreases accordingly. In the last analysis, high buildings beget high land values, land values which are speculative in nature, and it remains to be proven that such land values are a benefit to the community.

So far we have considered the effects of high buildings on street, traffic and transportation congestion, fire hazard, the health and the morals of the community. Now, it seems to me that we should give a little consideration to the aesthetic side of the question.

The American public have been slow to arise to an appreciation of the value of the appearance of the buildings of their cities, but it is a phase of the question which is receiving more attention from students of city planning, and eventually I believe will be considered as important as fire prevention, light or ventilation.

In cities where no plan exists, and where heights are not regulated, the streets become a hodge podge of sizes, shapes and arrangement of buildings. Side by side stand one and two-story tax payers, and towering skyscrapers. Buildings with facades of old and unsightly materials are flanked by buildings built of the best that the buildings trades can supply, while above our heads are signs, large and small, vertical and horizontal, together with marquees, balconies, large cornices, etc. It is indeed a strange assortment which meets the eye. Here let me quote from work on town planning by Mr. Triggs. He says:

"In this country, the interests and rights of the individual are so jealously guarded that improvements are always most difficult to effect, and street architecture has been hitherto allowed to take care of itself. Street architecture is social architecture and should surely conform to those rules of convention by which all society is governed. It should not be possible for any one freeholder to erect some vulgar monstrosity as an advertisement when such building destroys the artistic harmony of the street.

Of course it is obvious that if we were to have city planning and street architecture, a radical regulation of the height of buildings would be a fundamental part of any such program.

Now, let us turn our attention from the consideration of the evils growing out of the unlimited height of buildings and see what has been done, or proposed, in a remedial way. The cities of Europe are much older than our American cities and have had an opportunity to develop their building

regulations to a higher degree of perfection. We find that 29 European cities with height limits which range from 43 feet in Zurich to 82 feet in Vienna, have an average of but 67 feet, while the average for fifteen American cities having height limits is 166 feet, or nearly three times as great.

After a careful study of all existing regulations, the New York commission recommended making the height of buildings a function of the width of the street on which it faces, up to a certain maximum. They also propose dividing the city into a number of zones or districts, with the regulations in each district varied to suit the local condition. They start with a limit of one time the width of the street and a maximum of 100 feet. The next zone has a limit of one and one-fourth times the width of the street, with a maximum of 125 feet; the next one and one-half times the width of the street, with a maximum of 150 feet; the next two times the width of the street with a maximum of 200 feet, and the highest two and one-half times the width of the street, with a maximum of 250 feet.

While this latter is a very high limit, it must be borne in mind that they have had to give consideration to the large number of high buildings already in existence, some of which are nearly twice as high as the maximum they have set. Their rule was, therefore, relatively quite drastic, and if we were to reduce our height limit regulation in the same ratio the maximum height for a building in Cleveland would be about 110 feet.

We can feel sure that this commission, after three years of study on this problem, would not have made such sweeping recommendations if the evils of high buildings had not been entirely substantiated.

The Municipal Plans Commission of Seattle, Wash., published an interesting report in 1911 which deals extensively with height regulation, and it seems to me that one or two things which appear in that report would be interesting at this time. They say:

"That the skyscraper is unnecessary is quite apparent from the fact that the great cities of Europe and South America, those whose population approach or exceed a million, have grown to their present size and have conducted a commerce equal to that of our largest cities without the skyscraper as an adjunct and with every apparent indication that the rate of growth in commerce and population will be as rapid and as great as that of any modern city.

The necessity of the skyscraper is due solely to the attitude of the American mind, attaching more importance to individual property rights than to the importance of the community interested. Their removal can only be brought about by a change in the popular conception of the proper social relations."

Skyscrapers do not, by any means, denote the highest civic development —rather do they exemplify the utter lack of consideration for the better life of the city.

DISCUSSION

C. O. Palmer.—Did San Francisco limit the height of its buildings after the earthquake?

Virgil D. Allen.—I do not remember whether they passed any further legislation in San Francisco or not. They experienced interesting phenomena in that the fire absolutely got away from them and ran horizontally right through the top story of the high buildings. I do not now remember whether San Francisco has any building height limits. There are not many American cities that have height limits, although some of them have done fairly well in that respect. New York has taken a radical step by making into law last year the recommendations which I read to you, and dividing the city into zones. They have also done a great many other things in the way of increasing the

courts and yard sizes and trying to give air and sunlight to their buildings, as well as regulating the matter of height.

Some cities regulate building height by stories. For instance, one of the western cities sets the limit at twenty stories. You might have stories of varying height, and therefore that method does not limit the height of the building very effectively. Boston has limits that vary for different streets; so has Washington, and I believe that now the entire state of Massachusetts has a height limit, which I think is about 125 feet.

G. E. TOWER.—Mr. Allen spoke about the lower height of buildings in European countries. Is not that due to something else than the beautifying of the city, the civic spirit, or something of that sort? Personally I think it is due more to the fact that they use a class of material which would only allow them to go a certain height, at least I found that to be true in Cuba. I do not know much about Europe from personal experience, but I have seen pictures of many of the cities over there. Down in Havana, Cuba, all of the old buildings are approximately three stories high. Very few of them ever went as high as four stories. But now, since concrete and steel construction have come in, they have boosted their buildings up to at least eight stories high. I have thought that most of those foreign cities were built with the lower sky line because of the material they use rather than to any esthetic feeling in the matter.

VIRGIL D. ALLEN.—Well, undoubtedly all of these things have some influence and some bearing; but the European city governments have long realized the importance of limiting the height of buildings. One of the English cities, for instance, has a rule (I do not know that I can state it exactly, but I can give you the essence of it) that a man's building is entitled to all the light and air which would come within a line drawn at an angle of forty-five degrees to the horizontal, starting, I think, at the base of his building and going up across the street. Evidently they were looking out for light and air in that particular regulation, which would also act as a height regulation.

Nearly all of the important European cities have regulations which control the appearance of their buildings. They insist upon a certain degree of street architecture. I remember reading about one case where a man proposed to build a blank wall, which would face rather conspicuously on a street and the Building Commissioner, or whoever was in charge, ordered him to embellish that wall. He went to court about the matter, but was compelled to put in panel work, or in some way to embellish that wall to the satisfaction of the authorities. I think you will find that the regulation of building heights in Europe has been more on account of civic spirit than structural limitation. That is what I gather from my reading. As I read their laws and regulations, they preach all through them the idea that they want to maintain a street architecture, and that they keep building heights low both as a fire prevention and as a means of maintaining character to their cities. Because of this, our people go to Europe to see their cities.

G. E. TOWER.—Don't you think that is due to a great extent to the fact that most of these cities were old cities and they established this system at an early date, and now, of course, it is a pretty good plan to carry out the same idea, whereas in this country practically all of our cities are new, and we have developed the higher type of building construction more than they have? As to how much they have adopted the higher type in large cities like London and Paris, I do not know, but I will say that as far as I am concerned lower buildings, and especially the embellishments that they place on the fronts, make a much more beautiful appear-

ing city, having the sky line practically the same on a street, at least for several blocks.

VIRGIL D. ALLEN.—Well, it is true that their cities are old, but do not lose sight of the fact that they have had high buildings in Europe. The high building project goes back a long way in history. In Genesis we find mention made of the Tower of Babel, and I can show you still others almost as ancient. There was, for example, a very long litigation between the Emperor of Constantinople, the eastern division of the Roman Empire, and a resident of that city back in the third or fourth century, A. D., when Constantinople was made the eastern capital of the Empire. The real estate speculators arrived there promptly and began to make money by booming land values. The Emperor picked out a very beautiful site for his palace, on a hill which overlooked the water. This fellow picked out a piece of ground which was in front of the Emperor's proposed palace, and he erected a building of stone and brick five or six stories high, then built about four stories of wooden structure on top of that. The Building Commissioner of that time ordered him to take the wooden part off, but he refused and hired a good lawyer, and it took ten years for the Emperor to get the top pulled off that building, this fellow insisting that it was simply temporary, to be used by the workmen while completing the building below it, and he got by with it for ten years.

They had buildings in Jerusalem 100 feet high. In Rome they had plenty of high buildings, and they had a peculiar type of high buildings there, each story projecting out a little beyond the story below it, until on their narrower streets, many of which were only ten to twelve feet wide, the buildings actually met at the roof line, so that people could travel across the top of the buildings. And as they went up the stories grew lower until the top stories were only five or six feet high. So you will see that Europe has tried unregulated high buildings, and they have evidently seen evil effects from them. Some of the modern cities of Europe have curtailed them pretty sharply, and as I believe, with a knowledge of what they were doing.

I remember one peculiar regulation in one of the German cities where they had the Rathaus. That was three or four stories high, and it was the building of character in the town. One of the officials of the town was charged with this responsibility, to go daily to the tower of the building and look abroad, and anybody's building which was rising higher than the level of his eyes was stopped because they did not propose to have any building in that town dwarf this particular building. That certainly was a civic regulation. This was to maintain the superiority of the municipal building and had no other reason in fact.

A. F. BLASER.—In Berlin there is not a building more than five stories high, or if there is I have not seen it, unless it be the imperial dome which is, of course, not built in stories, and the two houses of parliament which are rather high buildings. But aside from that, all business blocks of every kind and description are not over five stories high, and they are limited to that by ordinance.

VIRGIL D. ALLEN.—I think about sixty feet is the limit.

A. F. BLASER.—And of course even then there are regulations beyond that in such a way that the basement story, for instance, cannot be occupied as a residence, neither can the last or upper story, which is rather in the nature of a half story.

But I am somewhat more interested in our own problems. There are many, and they are serious. If any such regulation should be adopted, I mean any regulation that would limit seriously the height which we now have, there are serious financial questions which, it seems to me, would

come up. People that own property in the down town section somewhere near the high buildings which we now have, would be seriously handicapped in developing that property. So it is a question whether it would not be an injustice to them to prevent their developing the property in the same way and in the same sense that the neighboring property has been developed. It is, therefore, not a simple question. I think it is one which deserves a great deal more discussion.

Virgil D. Allen.—I might add one other thing partly in answer to what Mr. Tower has asked. It is quite a common, and I might also say a general regulation, I think, in those European height limits that you can go up so high and then you have got to begin setting back the face of your building at an angle to the horizontal of thirty to sixty degrees, and you can go up some higher on that angle. Such regulations are based on the idea of letting the sunlight reach the street. Yesterday on the north side of Euclid avenue at 2:30 in the afternoon, I walked up against the building and looked to see if the sun was visible over the lowest building on the opposite side of the street, and I could not see the sun. I was thinking about this problem of how high a building would have to be to shut out the sunlight and all of the sunlight was actually shut out from the north side of the street surface. Of course, it is also shut out from the south side. It probably gets in the second story windows on the north side only.

L. K. Baker.—How do the conditions in Cleveland compare to the code you spoke of?

Virgil D. Allen.—There is no regulation here which acts such as the New York regulation, that is, making the height a function of the width of the street. There is a definite limit of height set in the Eisenman code of 200 feet as the highest building, and the height runs down according to the type of construction. A joist type of building may be sixty feet high, and then there was another height set at a hundred feet and so on up. Concrete buildings are 125 feet, but the Council, when the Guardian building was built, saw fit to increase the limit of the code, I think, about 15 feet, so the maximum height limit for a first class building became 215 feet. If you want to know the relation to the width of the street, I think Euclid avenue is 100 feet wide, which would make it 2.15 feet times the street width; whereas Vincent street is about 50 feet wide, which would make it about four times the width of the street. I think that method of regulating, by the way, that is, making the height of the building a function of the street, is a sane and proper method; it seems to me the only logical way that you can arrive at a rule. The other thing is entirely arbitrary. You are trying to get the sunlight into your street and into your courts and yards, and it seems to me that a consideration of the vertical angles is the thing which will have to govern. You can give a reason for it, and these other regulations, that is, simply saying 200 feet is an arbitrary rule with no reason back of it except some person's opinion.

R. B. Clapp.—Suppose a building runs clear through from one street to another. On one side it faces a broad avenue, and on the other a narrow street. Which width would govern in that case?

Virgil D. Allen.—I think the New York regulations provide when you go back about sixty feet from the wider street with the high part and then you drop down and make the height of the rear of your building conform to the narrow street on which it faces. All those things, of course, inject difficulties into the problem. The question of buildings running through from different width streets, and where the ground falls off sharply so that there is a difference between

one street and another of a story in height, and when it is on a corner where one street is wide and the other narrow, those all interject problems, but on these things as a rule a fair compromise can be made.

Silas Hunter.—Would you care to express your opinion in regard to the comparative beauty of the Society for Savings and the Federal building? As I understand, the Federal building is supposed to be absolutely perfect, and many of us do not see it that way.

Virgil D. Allen.—Well, I do not know that I am prepared to discuss architecture, as engineering is my line. I will say frankly to you that I have never been so enthusiastic over the classical orders of architecture for utility buildings. It seems to me that this age should develop a type of architecture which commends itself and fits in more to commercial uses than the old classical orders. If I am correctly informed on the history of architecture, the classical architecture was developed when they were building temples to their gods, and a building which was to be used as a place of worship is one in which the questions of light and ventilation are not serious problems. I would say that one way by which we might make beautiful cities would be to divide them up into districts around centers or squares, with a building in the center of each square for some public service, and have all the buildings which face that square and the main building developed to one order of architecture. You could use any one of the classical orders, or you can devise some new one. I think that method would give you excellent effects.

J. E. Washburn.—How does the effect of the earth structure, soil, foundations, limit the height of buildings?

Virgil D. Allen.—That does not come in to any great extent. They get buildings up in Chicago where they have no foundation at all. They are beginning to slide into the subways a little, but outside of that they have no trouble. The height must be limited for some other reason. Almost any height is an engineering possibility. As I said in my paper, we must consider the social life of our communities when regulating the height of buildings.

I would much rather talk to you on economics than buildings, because that is really the thing that is facing us right now, and if I may digress just a moment I may say to you that this war, as I see it, is not a war, but it is the breaking down of the type of civilization we now have. We have an order of things which does not fit, and we must have an entirely new order before we get on firm ground again. We have to realize that the purpose of life is something else than most of us have heretofore thought, that purpose as I reason, is the development of each individual to his capacity, physically, intellectually and morally. Make that the purpose of human life rather than the acquisition of wealth or of many other things that people are now doing and you would never have any need for many of the conditions which are now thought necessary to civilization. A large part of our human energy is now used up in doing things which, so far as I can see, are nothing but human waste. I think the skyscraper is just one expression of it. There is, of course, the argument that they bring people together in a mass, which makes them more efficient. Up to a certain point that is probably true, but when we get eighteen or twenty-story buildings jammed together, we have long since passed that efficiency limit and are, in fact, injuring the life of our community.

Note the experience of England about which I told you, where 72 per cent of the men in the cities were rejected as unfit for military service. That is three out of every four men were unfit for military service and that because of the conditions of life under which they lived. I venture

a guess if you will go back in the history of England three and four hundred years before the big buildings and industrial centers arose that you could not find one man in ten that you would have to reject. The quality of those old English yeomen and their military achievements is an open book to all of us who read history.

O. F. PALMER.—What, in your opinion, seems to be the real reason for building such high buildings? Is it a money proposition, or is every fellow trying to erect a monument for himself to try to beat the other fellow?

VIRGIL D. ALLEN.—I think it is nothing in the world but our land system. We countenance unlimited land values in a city and when you get a very high land value you have to put a high building on it to make it a commercial success. Now, if you will deal with the land question, you will deal with the high building question automatically.

SILAS HUNTER.—Don't you think that you will have to deal with the limitation first?

VIRGIL D. ALLEN.—Suppose that all taxation was put on the value of the land. A man then would be taxed no more if he put a $5,000,000 building on a piece of land than he would if he put a $1,000,000 building there.

SILAS HUNTER.—So the limitation of the building would have to come before the taxing of the land?

VIRGIL D. ALLEN.—I do not agree with you on that. The first thing to do is to have a foundation to build a building on. The land question is first. The land question is primarily the thing.

I have in mind a case where it is proposed to build a large building upon a site in this city. I think the land is on the tax duplicate for about three or four hundred dollars a front foot. So far as I know, nothing has ever been built on that land. There may have been something built on it, but I guess that land is about as it was when Moses Cleaveland surveyed around here, except the trees are off it. There may have been fences on it, but it certainly does not show much sign of improvement. If the people who want to improve that land take it, they have got to give a lease on a basis of about $1500 per front foot. Now, in order to make that pay it is necessary to build a high building. If the taxes were put up to what they ought to be, that is, loaded onto that land, the owner could not stand out. As it is, he can stand these people off because he knows somebody else has got to take it. In the meantime, it may rise until he can get $1600 or even $2000 a front foot, because land only a little way off is bearing as much as $2000 a front foot. So he is going to stand pat. He is making money by waiting. If you took this value away from him while he was waiting, he could not wait, that is all. He would give these people a chance to go in and do something. At bottom it is a land value question.

A. F. BLASER.—I would like to ask Mr. Allen, when the time comes to reduce this matter to ordinance form, whether it should properly become a part of the building code, or whether it is part of some other regulation like a street regulation, that is, an ordinance separate and distinct from the building code?

VIRGIL D. ALLEN.—No, it is undoubtedly a building code regulation. All building regulations, in my opinion, should be centered in the building department. Unfortunately, you have quite a number of departments handling buildings. I understand Chief Wallace is going to talk to you in a few days, and the Chief has some men in his department who are handling building problems more or less. Now, that in my opinion, is a mistake. I experienced a good many difficulties in trying to enforce building regulations, because there is a divided authority between the police department,

the fire department, the building department, the sanitary department and the state organization, and it makes it a very complex situation. I would urge that all your building regulations be a part of the building code and enforced by the building commissioner.

ED. LINDERS.—Is not the building code in its present form too cumbersome to handle?

VIRGIL D. ALLEN.—Yes, but it will take some time before you get out of that difficulty. It is my notion that so far as possible, building code regulations should be written on the basis of performance rather than on the basis of specifications. I can illustrate that by one example, and enough study, I think, could reduce a good many of the regulations to that form. Suppose you wish to specify a fire wall; now our code says it is a 13-inch brick wall. That precludes anything else but a solid brick wall 13 inches thick. We may have a fire-resisting material better than a brick wall, but nevertheless the Building Commissioner would be compelled, if he lived strictly within his code, and he has no business to do any thing else, to rule it out. My notion of that is that instead of the code calling for a special wall, it shall require the wall to do a certain thing, viz.: that it should resist a fire of a certain temperature for a given number of hours, and not transmit more heat than would enflame certain materials at say 400 degrees on the back of the wall, and when the fire is quenched with water there will remain a stable wall. Of course a laboratory test would be required to determine this. A man might come along with a wall four inches thick which would be a better fire-resisting wall than a 13-inch brick wall. It would certainly save a lot of weight if that could be done. I think a building code written on performance rather than on specified material would be a very great improvement, and I believe that sometime, someone will have the vision and patience to do it. A good deal of the code could be so written. If you wanted to have fire walls, and fire resisting partitions, you could write a specified performance for each one down to 1500 degrees and fifteen-minute service and then you could say under certain conditions you would have a fire wall, and under other conditions you would have a fire-resisting wall, and under others, fire partitions, and under others fire-resisting partitions, and so on. That form of code will come some time. Codes have been written under stress. I was asked if they did anything about the code in San Francisco after the fire. Probably they did. After the Iroquois theater, they wrote a lot of things into the codes, all over the country. These things are not well thought out. They are copied one from another and such provisions do not match up well with the rest of the code, and so they build up codes piece by piece. You should not write your regulations that way. They should be written from an entirely different viewpoint.

I remember distinctly about the last code I saw come into the Building Department. It came from one of the far western cities, and it had a great flourish of names and promises on the title page. I thought, this is something fine, and opened it with a good deal of interest, only to find it was a copy, dot for dot and word for word, page after page, of the old Eisenman code we had been working years to correct.

Another great trouble for a code writer is that people want to sell things through a building code. It is the finest way on earth to sell something. Just write it into the law of your city that the people of your city must use a certain material or device and you can take your salesmen off the job. It is a very great mistake to do that, and yet most building codes are full of it.

K. H. OSBORN.—Tampering with our code to take care of the Guardian building produced an interesting situa-

tion. I happened to read over the amended form of that section of our code governing the height of buildings a few days ago and was reminded of the fact that as originally written it mentioned the figure 200 feet as the maximum height three times. The man who wrote the amendment looked at one section and made it read 215. As a result our ordinance now reads that you shall go "not more than 200 feet", and then it says you may go 215 feet, and in the last paragraph it says, you shall in no case exceed 200 feet.

Virgil D. Allen.—I would probably have found that if the Council had consulted me on it, but they did not do it.

K. H. Osborn.—I know it was not with your consent that that went through at all.

H. H. Smith.—Would it not work to the benefit of Cleveland if they limited the height to the width of the street, and as long as Superior avenue is wider than Euclid, drive some of the large buildings onto Superior?

Virgil D. Allen.—Yes, sir, it would have a tendency that way.

C. O. Palmer.—Don't you think it would be a good thing to tax the land on which higher buildings are put at a greater rate per foot than if the buildings were lower, or at least beyond a certain limit?

Virgil D. Allen.—You may go just as far as you like in putting taxes on land values, so far as I am concerned.

I want to say a word on another subject since the questions are ended. I want to make an appeal to the engineers. The engineer, as a class, is perhaps the best trained thinking machine we have in our modern life. I am not jollying you at all, I mean it, and yet unfortunately he has let other professions and other classes of men run away with the problems which he should be solving. I mean by that just this: That our modern civic problems, our municipal problems, are engineering problems. What, for example, are the mayor's duties? In my opinion, 90 per cent of his problems are strictly engineering problems; the other 10 per cent may be a mixture of law and common sense, and perhaps more common sense than law. Your streets, your sewers, your docks, your harbors, your transportation, your buildings, all those things involve engineering problems.

It seems to me that if we are going to have real cities, and the hope of the world lies in the cities, the engineer must take his place in the handling of the city problems; and we have got to insist that the form of our city government be such that the engineer can take his place. You men are in a position to cast your influence that way in Cleveland, and you should do it. We need an engineering organization in our city from top to bottom. I tried to create an engineering organization in the Building Department, and it should be an engineering organization. I do not know of many departments in the City Hall that should not have engineering organizations, and they would then get vastly better results for our city. I am sorry to see the handling of our great cities in the hands of men who have no conception of these problems at all. I do not criticize the men—it is not their fault. It is our fault. It is our business to see that we get over doing that sort of thing. We have got to conceive our city organizations as being something else than a place for men who can be successful in getting votes. We should stop electing the men who handle our municipal problems. We have got to do it some other way, because we cannot elect men who at the same time have a technical knowledge. Men who have technical training are not, as a rule, the kind of men who will command general attention from the public, and that is the only kind of a man who can be elected to public office in a scramble for votes.

Now I feel strongly on that subject, and I do not want you to take anything that I say as being in any way personal as against this or any other administration that our city has had. I do not feel that way about it. That is not the idea. I am not blaming anybody except myself and yourselves. The fact is we have not realized what kind of a problem our cities have grown into. There was a time when cities were such that almost anyone could run them, but that time has passed, and now you must have men on the job who are trained for the work, and that will make the great opportunity for engineers. When city administrations really are made into engineering organizations, it will be one of the finest engineering fields there is because the problems are large, they continue over years, and they give an engineer an opportunity of development which he cannot get in private practice. When we get this condition, we will develop a very different type of city from any we have thus far seen in this country.

Manufacture, Inspection, Etc., of Crucible Steel

By F. B. Lounsbery*

Paper Presented Jan. 8, 1918.

Index No. 620.17

I regret that I was not advised until the last few days that I was to give this address and consequently I have not prepared any special paper. However, the pictures are very descriptive in themselves and I will further describe them as shown.

If there are any questions you would like to ask as the pictures are being shown, if you will just speak up, we will be glad to stop the machine at that point and attempt to explain whatever process is being shown. Also in between the reels if there are any questions, I will be glad to answer whatever I can.

Motion Pictures

One of the first difficulties the steel maker encounters in producing his product is obtaining sound ingots. By this I mean obtaining ingots free from segregation, blow holes, surface defects and particularly pipe. Pipe is a term applied to the shrink cavity which forms in a steel ingot as it solidifies in the mould and is caused by the contraction of the metal in solidifying. Various schemes and devices are used for overcoming this difficulty, both mechanical and physical with limited success. One method is to use hot tops or dazzlers on moulds when casting ingots, to help overcome this condition. These are made of fire clay and heated to 1800 degrees Fahrenheit before placing on mould. This particular feature has been very beneficial in eliminating the pipe in small ingots, in that it keeps the metal in the top of the ingot in a fluid state and as the shrink cavity forms the molten metal sinks down and fills it up. In this way whatever pipe does form is confined to the top of the ingot and can be readily cropped off.

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Secondary pipe is another objectionable feature which occurs in ingots. This is a porous condition or actual cavity which sometimes exists down inside the ingot and has no opening through the top. In other words the ingot will be solid both top and bottom and yet contain a cavity in its interior which probably will not be caught until ingot has been worked down into a billet or even to the finished bar. The use of taper ingot moulds has to a certain extent removed this source of trouble in that the solidification and contraction takes place at the bottom first, which is smaller in cross-sectional area and proceeds upward. This prevents the ingot from solidifying across at the top of ingot and leaving in the center molten steel which upon solidification contracts away leaving a cavity or at least a porous condition.

W. L. Ely.—How many heats will the crucibles run?

F. B. Lounsberry.—We ordinarily get about four to five heats a day out of each furnace. That would be five heats of thirty pots each; in other words 150 pots, and the average weight would be eighty-five to ninety-five pounds. The number of heats as well as the weight produced depends upon the type of steel melted.

W. L. Ely.—You spoke of not using the mechanical devices in lifting the pots out of the furnaces. It strikes me that weighing and proportioning could be done mechanically?

F. B. Lounsberry.—There are many different raw materials that go into the mix and it is necessary to know accurately the analysis of each one of the ingredients that go into it. There are two, three or more different kinds of scrap that go into this 90 pounds, in addition to the virgin

material and the alloys: so I really do not see how you could use mechanical devices, because it has to be selected.

Q.—Is there any remedy when you get a pipe in an ingot except remelting?

F. B. Lounsberry.—There are various theories. Some metallurgists claim that small or secondary pipes which are ordinarily called blow holes, will weld together in the forging operation. This may be true of straight carbon steels, but I am positive in high speed steels or steels containing tungsten or chromium in appreciable quantities, they do not weld up, but instead they expand and become elongated. But in carbon steels, and especialy in the lower tempers of carbon steels, the possibilities are that pipes or blow holes, which have not been oxidized, that have never been exposed so that the surfaces are oxidized, will weld up. However if they are open and the surface has become oxidized, then they will not weld up, and if you have a piped ingot to begin with, the chances are you will get a piped material. The best way to eliminate the pipe in bars is to prevent piping from taking place in the ingots. This can be done by continually splitting ingots and seeing what condition they are in.

Regarding Losses and Recoveries

The high speed scale, as well as the grindings, can be recovered. This is accomplished by reducing the scale in small built-up electrical furnaces, and reconverting it into ferro-tungsten; so that there is really not much loss.

W. L. Ely.—Is there any special advantage in using a steam hammer instead of a press? I notice for large shaping they use presses. Is it quicker?

F. B. Lounsberry.—There is for tool steel work. It is characteristic of tool steel and high carbon steels, and especially tungsten steels that they will not stand drastic action. Under a hydraulic press the action is very drastic, and they will not stand it. As a matter of fact, I have seen this tried, and for high carbon tool steel work, and especially high speed steel the press does not work out satisfactorily. It has been my experience that a press is really faster. On steels like automobile steels, chrome-vanadiums, chrome-nickels, 3½ per cent nickels and steels of that type, a press is very well adapted and produces good billets.

W. L. Ely.—It occurred to me that the hammer blow would tend to produce pipes much more than a press. You will notice the end of a shaft that has been pressed will bulge out in the center, and a hammer shaft will be concave in the end.

F. B. Lounsberry.—That is very true. With the press the work absolutely goes all the way through the metal which is evidenced as you have pointed out, by the fact that the material will be bulged on the sides. It has only been recently that tool steel makers have endeavored to roll high speed steels and tungsten steels in any appreciable size, but at the present time they have worked this out so that fairly good sized high speed bars can be rolled.

Q.—In the annealing of billets, how long is the temperature held at 1500 degrees, how long does it take to cool and at what temperature are the bars withdrawn from the annealing furnace?

F. B. Lounsberry.—In our case the furnace is charged up at about four o'clock in the morning, firing is started about six o'clock, and we have in the neighborhood of about five tons of ingots in the furnace. This would be fired until about eleven o'clock in the morning to reach 1600 degrees, then it would be held at 1600 degrees until about four o'clock in the afternoon, then allowed to cool from that time until midnight. When they are removed from the furnace, they are down below a black, I should say in the neighborhood of 800 or 900 degrees Fahrenheit. In other words, five hours coming up to temperature, five

hours at temperature and eight to ten hours cooling.

There are various ideas on annealing high speed steel. Some people anneal high speed steel at about 1400 degrees Fahrenheit. I know a concern in your own city which gets very good results in annealing high speed steel at 1400 degrees Fahrenheit. I have tried it and I find I get a Brinell hardness of about 400. They seem to be able to anneal it at that temperature and get it soft enough for their operations. Of course, that does not mean it will always machine, because a machine operator, no matter what happens, if he does not get the piece through, says the steel is hard. A great many times, and probably 50 per cent of those times the steel is too soft rather than too hard, and he gets a tearing action and it does not machine smoothly. It is hard to machine, but it is not due to the piece being hard, it is due to its being too soft; yet they always speak of it as the steel being hard. I presume you have all encountered this condition.

Q.—Is it a fact that the higher the percentage of tungsten in high speed steel the more brittle it is, or is there some other element that produces that?

F. B. LOUNSBERRY.—It has been proved to the satisfaction of myself and others, by experiment and through the papers which have appeared in the British Iron and Steel Institute, that it is chromium and not tungsten which gives the hardness to high speed steel, and this was arrived at in this way: Professor Edwards made up a series of steels which had no tungsten in them, but varying percentages of chromium, and the other elements constant. Then he made another set of steels in which the tungsten was the variable, and ran tests on these different steels, proving conclusively that the self-hardening which we find in high speed steel is due to the chromium and not to the tungsten; but that the *red* hardness which we term *red* hardness, in other words, the ability of a tool to maintain its hardness and its cutting efficiency at high temperatures, was due to the tungsten and not the chromium.

J. E. WASHBURN.—What do you find to be the characteristic difference shown by the scleroscope and by the Brinell machine? In other words, why do you use the two?

F. B. LOUNSBERRY.—Certain customers ask for a scleroscope hardness, and certain others a Brinell hardness. I personally prefer the Brinell test because I do not feel the scleroscope is very reliable on this type of work. Operators do not take the time to smooth the surface, which you all know is necessary in order to get a reliable scleroscope test. But this is the reason for making both tests. Of course, one method acts in a way as a check against the other; but that is not very important.

W. L. ELY.—You spoke of the electric furnace as being able to melt equally well with crucibles, etc. Do you get the advantage of more heats out of the electric furnace in the same length of time?

F. B. LOUNSBERRY.—The length of time in either case depends on the type of steel that you are melting. With carbon steel, especially a high carbon steel which melts down very rapidly, we can get a heat out of the crucible furnace in about four hours, or slightly under; that is, from the time you put the heat on until that heat is ready to pull. In the electric furnace you can do just about the same, but if you are running a tungsten steel in the crucible furnace it takes five, five and one-half and maybe six hours to get that out. The advantage of the electric furnace is in the quantity, uniformity and quality of the heat. In the crucible furnace we get out 2700 to 2800 pounds, whereas in the same length of time in the electric furnace we can get out three tons.

There are certain grades of steel we have never been able to make in the electric furnace satisfactory to ourselves. One of them is high speed steel. We are not able to get as uni-

form and homogeneous a high speed steel out of the electric as we have been out of the crucible furnace. Take 3 per cent chromium steel and even this new type of valve steel which is used for government aeroplane valves, all can be made very satisfactorily in an electric furnace; but we do not seem to be able to make high tungsten steels, and I think this is because the tungsten, due to its specific gravity, settles into the bottom of the furnace which does not have the circulation to circulate it uniformly throughout the bath. In the crucible you have the same tendency, but it is a good deal smaller quantities, being in a number of different pots which when they are all dumped into a ladle tend to mix up and to be uniform. The Heroult furnace is only heated by electrodes through the top and heating in the furnace is principally due to the heat from the arc. There are certain types of electric furnaces which have an electrode come up through the bottom of the furnace. In this type of furnace you get better circulation, because the bottom is hotter and the metal consequently circulates better; however, they have so many other disadvantages that they have not been universally adopted in this country. The Heroult furnace is by far the most practical and best furnace to date.

W. L. Ely.—I understood in making steel castings you got from one to two more heats a day out of the electric furnace than you did out of the crucible.

F. B. Lounsberry.—No, we figure on getting out about five heats a day out of the electric. We get probably a half a heat a day more out of the electric than we do out of the crucible furnace, but that difference is more due to the fact of the difference in the steel analysis. Of course, we could only melt a great deal faster in the electric furnace if we used more current. The more current you put into the furnaces the faster it will melt down. These furnaces use about 750 K. V. A. in melting. It takes the same number of B. T. U.'s to melt a charge regardless of how this heat is supplied.

R. M. Morgan.—You mean by that that the cost per ton of fuel is the same in either furnace?

F. B. Lounsberry.—No, sir, I do not, the crucible cost is about double that of the electric.

R. M. Morgan.—Is that not due more to the cost of the pots than the fuel cost alone?

F. B. Lounsberry.—It is not entirely due to the fuel. It is due to the labor and the selection of material, the cost of pots, and all the factors that enter into that. Take for example this three-ton electric furnace, there are only fifteen men required for operating that furnace day and night; eight men on days and seven men on nights. In the crucible department for both furnaces whose combined capacities are only about half what the electric furnace is, we have about thirty on day and night. The labor cost is high on the crucible furnace, because it is all hand work.

R. M. Morgan.—What I meant was the fuel, say the gas compared with the electricity. Has there any cost been established on that exclusive of the labor? Of course, we can see where the labor would be greater on the crucible than on the electric.

F. B. Lounsberry.—I cannot give you any definite figures on that, but I believe the cost of the electric would be slightly greater than gas. Possibly some of you engineers would know more about that than I do. But I think that would be the case.

J. H. Herron.—You spoke about the tungsten steel made by the electric furnace not being as good as that made in the crucibles. What is the difference in the physical properties and structure? You spoke of the segregation or the tendency of the tungsten to settle to the bottom. Would not that be thoroughly mixed when poured into the ladle?

F. B. Lounsberry.—It would not in just the ladle itself. There are certain concerns in the country which are making lots of electric furnace steel. Some of them reteem the melt. They tap it out into a ladle and then they reteem it into another ladle which they cast from, in order to stir and mix up the metal. Why I say we have not been able to make as good high speed steel is because our losses, in the first place, have been greater per weight of ingots than they have been from a corresponding weight of crucible ingots. Our losses have been greater in scrap, there is a greater tendency to seam, and in addition to that in the finished bars which are able to make and run actual cutting tests on we found in all cases the crucible high speed steel showed better results than the electric high speed steel.

F. C. Parsons.—What experiments do you use to test the durability of steel? You said the Brinell instrument did not show the machining qualities of the steel.

F. B. Lounsberry.—Almost all concerns who are using high speed steels or even carbon steels work up their own tests. Olsen has developed a machine for testing machine-ability, which depends upon the work done by a drill. Whether that is a true representative of the machining properties of steel I am not prepared to say. I do not believe it is. I myself did some experimenting with a lathe by connecting instruments to it and attempted to measure the power consumed for a constant cut and feed, using a standard tool; that is, ground to standard shape, and let the power consumed represent the machining factor. For example, if the piece was hard, naturally more power would be consumed to do that cut and vice versa; but I did not get very far as it did not seem to be reliable. Firms develop their own tests which they follow for their particular use, because what is soft for one person is hard for another. Take for example, tap steel does not want to be very soft; that is dead soft, because the chief requisite here is to machine smoothly and leave perfectly smooth surface. A steel in what we call the spheroidal condition, that is, where all the carbides are collected together in small globules or spheroids, will tear upon machining and not leave a smooth cut. It is soft to test, but it will tear out; a free machining carbon steel will show more or less pearlitic condition, possibly lamellar.

J. H. Herron.—What standard of Brinell hardness do you have for the annealed condition of both the high speed and the carbon steels?

F. B. Lounsberry.—On the high speed steel we endeavor to maintain a hardness of under 250, but we rarely ever get a heat in which there will not be a few pieces tested which go over that. They usually run all the way from 212 up to about 255 and possibly 260, but anything that goes over that we reject for reannealing. On the carbon steels we endeavor to maintain a hardness of 180 or under. On vanadium tool steel we try to maintain a hardness around 190. On chromium steel, that is, 3 per cent chrome alloy, tool steel, we endeavor to keep under 200. On oil hardening, non-shrinking tool with which you all are familiar, containing about 0.85 per cent carbon and 1.25 per cent to 1.50 per cent, possibly higher, manganese, we are not able to get a hardness any lower than that about 200 to 208. It seems as though this steel ought to anneal very readily, but it does not. As a matter of fact, the best way to get this steel soft is to quench it first or to normalize it. Either give it a normalizing treatment by heating it well over the decalescent point and then anneal it, or else heat it up and quench it in oil and then anneal it. Ordinary annealing will not anneal it softer than about 200.

J. E. Washburn.—What does that

normalizing treatment do to the structure?

F. B. LOUNSBERRY.—I mean by the normalizing treatment putting it into a furnace, heating it up to approximately 1600 degrees Fahrenheit and allowing it to cool in the air. You have then developed in this steel a sorbitic structure. It is sorbitic and pearlitic. The object here is that you put the entire steel in a uniform condition to start your annealing. You remove all previous strains in the bar, and you have a uniform structure to start your annealing with.

J. E. WASHBURN.—Is that for high speed steel?

F. B. LOUNSBERRY.—No, sir; I am speaking of the oil-hardening steel. With high speed steel it is not necessary to do that. You can get a satisfactory annealing just with the regular procedure.

J. E. WASHBURN.—On that normalizing, what is the difference in cooling in air and cooling in oil? Would you get better distribution by cooling in oil?

F. B. LOUNSBERRY.—I think possibly you would. As a matter of fact, I prefer on this type of steel to quench in oil rather than to quench in air.

J. E. WASHBURN.—About what hardness do you get then? Quenched in oil-scleroscope?

F. B. LOUNSBERRY.—You get a hardness of about 75 to 80, depending on the sectional area of the bar.

Development of the Electric Traveling Crane

By T. E. Austin*

Paper Presented October 2, 1917.

Index No. 621.87

It goes without saying that I highly appreciate the honor of being called upon to speak to you—I will not say MEN—for in the American engineer we find the SUPERMAN of the age of which the philosophers of old obtained a vision, the engineer that man will ultimately recognize as the creator on the earth. Long unknown, unhonored, unrecognized, but destined by the virile facts of his acts and education to take a leading and vital part in the reconstruction of the world after the terrible time through which we are now passing, and to which by necessity, I am compelled to refer, is over.

Man, everywhere, is asking the question, "After the war, what?" The answer in large part as well as the successful progression of the war will depend upon the engineer, and how well he realizes, responds and rises to his responsibilities and opportunities.

Like Atlas of old, today the whole superstructure of the world rests upon you, and I believe the world will find you a solid foundation upon which it can securely repose, realizing as you must, the true analogy between cause and effect, which is exemplified in everything you do or dream, and speaking of the engineers' dream, which has been largely the base of progress in the human welfare of the world, because he has been a man with a dream—with a vision; that's it, the man with a vision—who has increased production, which is the only real wealth, efficiency and progress or conveniences of life until today the ordinary laborer lives better than the Queen of England lived in the days of Elizabeth.

Compare the man of vision, the engineer, with that class that usurps 90 per cent of the political positions and power in America (with the consent and will of the people if you please). The lawyer, that giant colossal, standing between the people and the light, spending his life looking backward, ruled by precedent, and such men on the advisory or Naval Consulting Board as say Howard E. Coffin, who was responsible, I believe, for the card indexing of the mechanical and manufacturing resources of the country, thereby giving the Government in a day of trial the necessary information as to where to turn for efficient assistance.

Not only is the engineer pre-eminent in the work of carrying on the world war to a successful conclusion, but also in the victory of peace, how vital his services. Who in his unassuming way has done more for the consummation of that noble christian ideal—the "Brotherhood of Man", exemplified by the Great Teacher in the words "Our Father who art in Heaven", because the engineer has banished darkness, eliminated time, overcome distance and brought not only America but the whole world in closer contact, giving each one of us the privilege of that personal touch that makes for understanding and appreciation which is the first step in the brotherhood of man.

I was much impressed by the address of John B. Finley, vice president of the Federal Land Bank of Baltimore, before the Association of the Iron and Steel Electrical Engineers on the occasion of their eleventh annual dinner at the Bellevue-Stratford hotel, Philadelphia, on September 12th, wherein he described being at the convention of the National Chamber of Commerce in Washington where the representative of the

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American Telephone Company called Pittsburgh; Pittsburgh called Chicago; Chicago called Denver; Denver called some town in Nevada (not Reno), and Nevada called San Francisco, where a special transmitter was connected at the Cliff House where the waves of the Pacific ocean dash against the rocks; then the lights in the room in Washington went out and there was flashed upon the screen a picture of the scene transpiring on the far Pacific coast some 3700 miles away and you could hear the call of the sea lion, the dash of the waves, and the surging of the tide in that far distant place. An amazing accomplishment of science and the engineer, to whom it would appear all things are possible. In these days when the best efforts of every man, regardless of his previous condition, are imperatively needed for the benefit of our country and while we may regret that we are in the fight, let us be like the Irishman who thought the best way to get out of the fight, now that we are in the fight, is to stay in. Therefore, as is always the case, intelligence and effort must ever bear the burden of the weaker and less fortunate brother, combining true economy and efficiency with the helping hand, the hand that helps the man to help himself, which is a different matter entirely from coddling or pampering. In this emergency we all need the best help obtainable to assist in bearing the world's burden, and in a peculiar though restricted sense, how well the modern electric

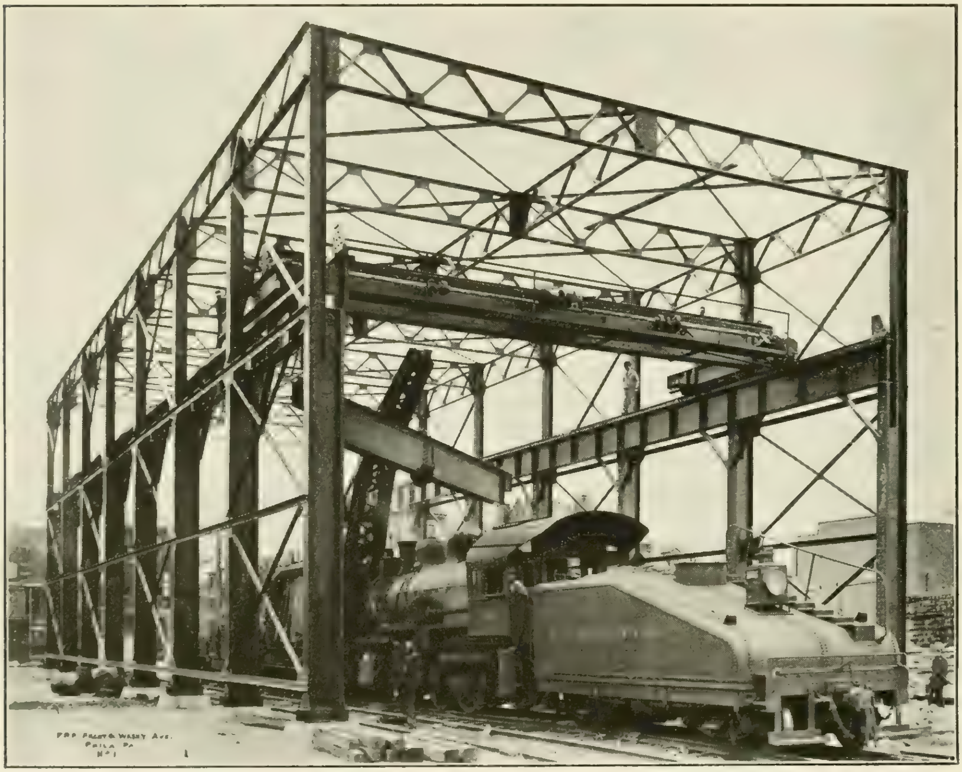


FIG. 1
40-Ton Electric Traveling Crane

traveling crane performs this function.

traveling crane, but with equal force and justice it can be safely stated

Fig. 2
Old Southwark Shot Tower

The claim is sometimes made that the steel plant developed the electric

that the electric traveling crane developed the steel plant. While as at

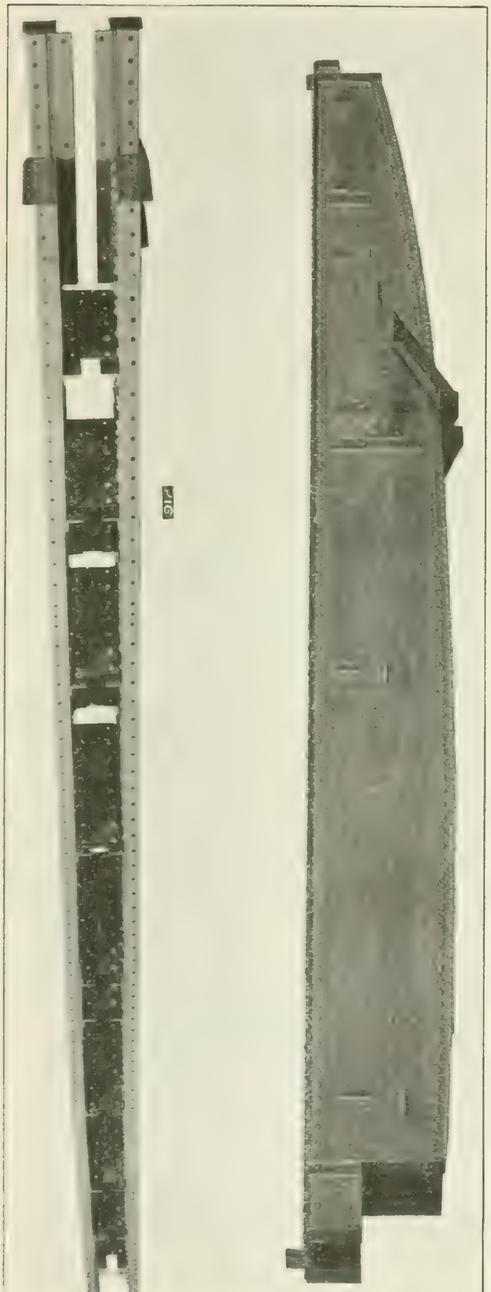


FIG. 3
Box-Section Type of Girder

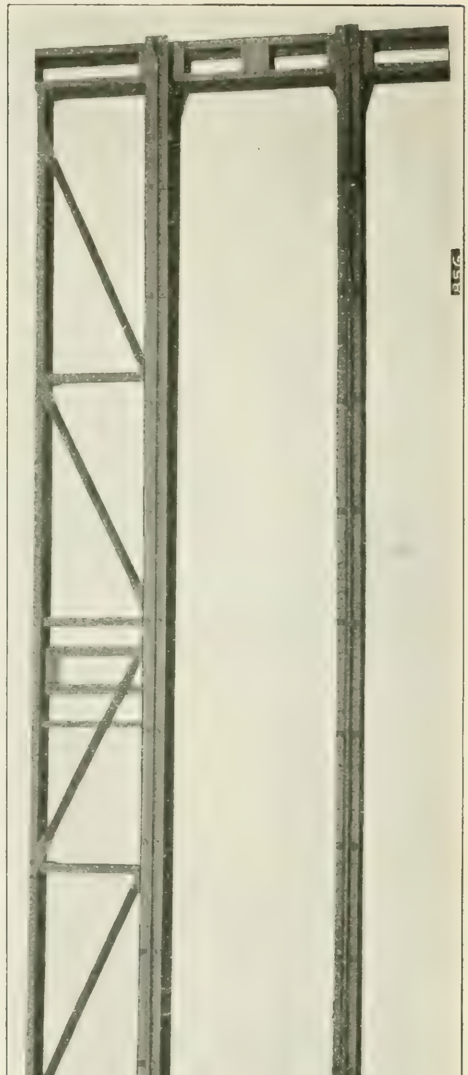


FIG. 4
Auxiliary Braced Girder

present constituted, the modern steel plant could not exist without the modern crane, the crane could exist without the modern steel plant, the electric traveling crane being a vital factor of economy in modern manufacturing methods, not only in the steel plant but in the iron and steel foundry, machine shop, stone and lumber industries, electric light and power plants, shipbuilding and the railroads whose glistening tracks span the earth. In each case, the electric traveling crane has been developed to suit the particular condition, to increase the output and to supply the most rapid and efficient method of handling material, and every day there is a new demand that taxes the experience and ingenuity of the crane engineer.

Let us enumerate a few of the essential points demanded of the modern electric traveling crane and after that we can briefly analyze some of the methods adopted to attain them.

One of the first principles of its design must be safety, that is, to be able to handle a load up to its rated capacity with a large margin of reserve strength to compensate for wear, use and abuse, so as not to endanger the life and limb of the operator or the men working beneath the crane by failure of the component parts or inadequate protection of the operator, and we may further add provision should be made to safeguard the man or men engaged in repairs.

Second. The crane should be quick-acting, responding immediately the current is turned on, so that all movements of the crane can be used simultaneously, obviating lost time in the prompt handling of materials.

Fig. 5
Lattice Type Girder

Third. The crane should be efficient in that if called upon to operate continuously for a long period of time it should be able to stand up to the work with the minimum delay for repairs or attention, secured only by proper lubrication and generous wearing parts carefully protected from dust and mechanical injury.

The regulation or control of the various movements of the crane should be such that the desired work can

be performed with exactitude and ease, the load being quickly transported to its desired location, leaving the crane free in the shortest possible space of time to do such other duties as it is called upon to perform.

All parts of the crane should be accessible for examination or repair, and each distinctive part readily removable when necessary. These parts should be compact, so as to be easily handled. To meet the foregoing demands different principles of construction have been utilized, varying with the individuality of the designer, and it frequently happens that a crane built to comply with the specifications of one department of a plant will not be accepted by another department of the same plant, though the work to be performed is identical.

While the construction of cranes in the different countries of Europe and the United States varies widely, the two most radically different specifications are found in the practice of some of the steel mills of America and the government of France; the one, to illustrate, specifying a battleship, the other a Ford.

We are now ready to start on our tour of investigation.

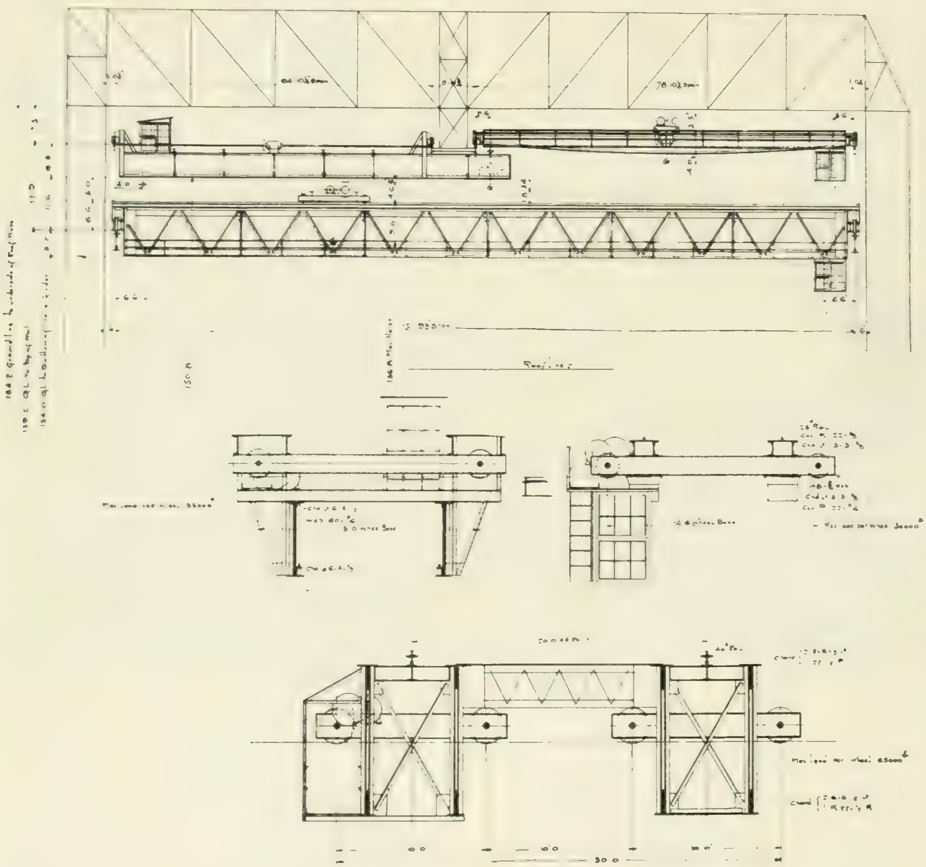


FIG. 6
Sketch Drawing of 40-Ton, 152-Ft. Crane

Light Out

Fig. 1 shows a recent installation in the new freight yards of the Penn-

sylvania railroad, foot of Washington avenue, Philadelphia, of a 40-ton electric traveling crane. To erect this crane a 150-ton capacity locomotive crane was used. The two bridge ends or trucks have been placed on the runway and lashed in position, and they are now lifting the girder intact with the bridge drive mechanism.

In Fig. 2 your attention is called to the old Southwark shot tower, the munition plant in the war of 1812 which was the main supply of Government ammunition. It was built by a bright Philadelphia plumber named Sparks and remained in the family for four generations. It has lately been acquired by the Philadelphia Board of Education and will be preserved to posterity as a children's playground. It is built of brick, 175 feet high, and is 20 feet in diameter at the bottom.

Let us at this time examine the details of what may be termed a standard crane that satisfactorily solves the general requirements of crane users, and is so arranged that the parts can be manufactured in stock.

In our analysis of this design let us start with the foundation of the crane, the girders.

Fig. 3 shows the generally approved type of crane girders in America which is the box section type. Each girder is composed of two web plates, universal mill top and bottom cover plates, and four chord angles running the entire length of the girder without splice.

The webb plates, you will note, are connected together at frequent intervals by diaphragm plates to prevent buckling and distortion of the girders by the bridge drive motor or gears. The time was when some builders made these separators of cast iron.

Fig. 4 shows another design of girder which has proven extremely satisfactory in use, and is known as the auxiliary braced girder. For long spans an additional vertical auxiliary brace is provided, which also serves as a hand rail for the platform, the auxiliary brace forming an ideal support for the bridge drive shafting, motors and gears, thus making active use of all the material without excessive weight.

The lattice type of girder shown in Fig. 5 is desirable in long span cranes and makes a rigid, stiff construction, light in weight but high in labor

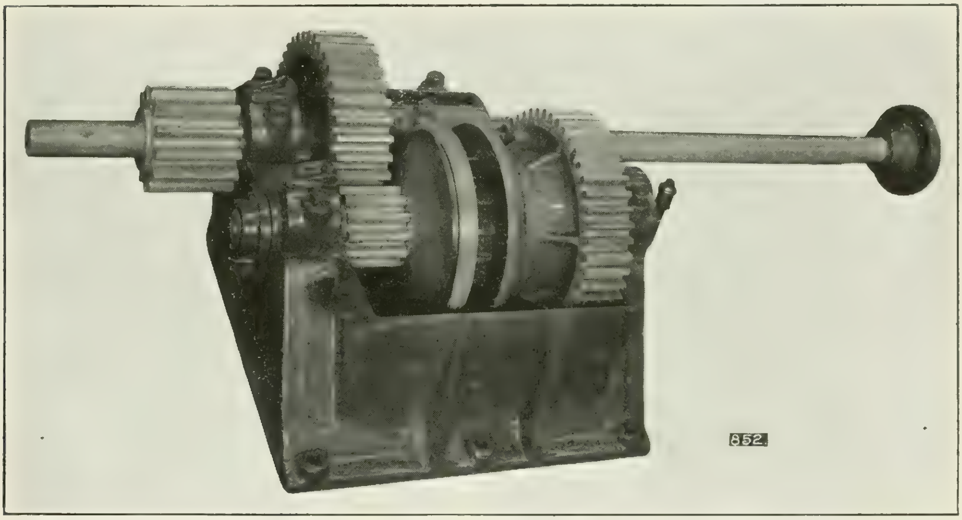


Fig. 7
Double Disc Mechanical Brake

construction cost, which has doubtless been one of the reasons why it has not become more popular in America, although introduced in this country a number of years ago. The first installation was at the American Car & Foundry Co., Detroit.

In these days of economy, conservation of power and "safety first" advocates, it would be well to pause a moment and ascertain whether the greater number of accidents are caused by the failure of the component parts of the crane in operation, or when the crane is laid up undergoing repairs. In other words, should not the scientific light weight of a crane, a moving object, receive the same careful consideration as an automobile. Does not a 6-inch angle iron toe-guard along the footwalk of a crane, specified by some users, cause more accidents than it prevents, due to the extra weight which causes wear and tear and increased repairs on the crane, thereby multiplying the possibility of accidents?

In Fig. 6 we see the reproduction of a sketch drawing showing a crane of 40-ton capacity, 152-foot span, 140-foot lift of hook. These girders are about 11 feet deep, a competitive design with box section girders, requiring a depth of about 25 feet, showing a saving of 14 feet in the height of the building for same lift of hook. In a building several hundred feet long these cranes save in the building cost alone more than the increased labor construction cost of the crane.

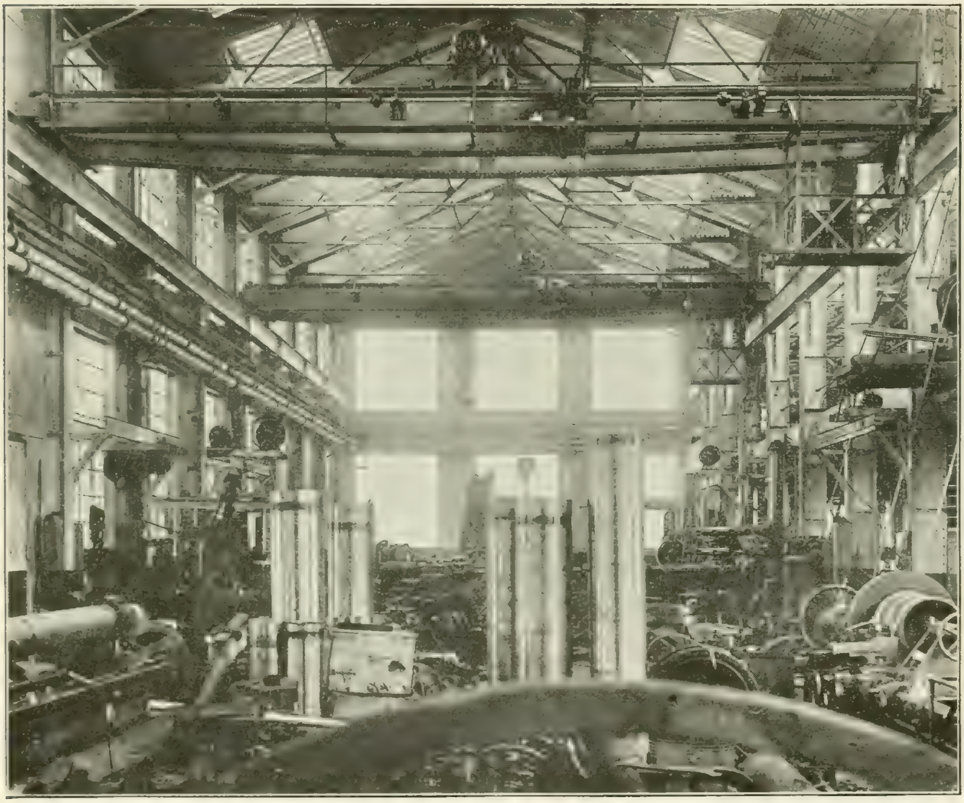


FIG. 8
Showing Cranes Operated by Alternating Current Motors

An entirely new feature has been introduced in the design of this crane in that all parts of the girders are active members. In the ordinary lattice girder, the inner member carries the entire weight of the trolley and its suspended load, the outer members forming an auxiliary brace. In this design, the trolley and load are carried in the center of the girder and all members bear an equal strain. These girders rest upon and should be securely fastened to bridge ends. We recommend wide gusset plates to prevent the girders from getting out of square and turned bolts in reamed holes for connecting these parts. Bridge ends are made of cast iron, steel castings or structural steel.

Originally I suppose crane manufacturers had a whaling big iron foundry, but were not so well equipped for fabricating structural steel, hence the original cast iron bridge ends with the consequent risk of failure through defective castings, due to shifting of cores, shrinkage cracks or other causes. The steel casting bridge end is an attempt to overcome these defects which are inherent in a casting of this kind and are still present in the steel casting, besides the useless excess weight that increases the wear on the motors, gears and bearings.

The cast iron bridge end allows the introduction of the M. C. B. type of truck wheel bearings, which makes a good appearance, but is of doubtful utility. In the structural steel ends, the engineer knows exactly what he has and all chance is eliminated. Failure is only possible by mistake in calculation. The dead weight is reduced to the safe minimum and the strain on the wearing parts reduced by that much. The truck wheel is held rigidly in line and cannot twist as may be possible with the M. C. B. type of bearing, due to uneven track

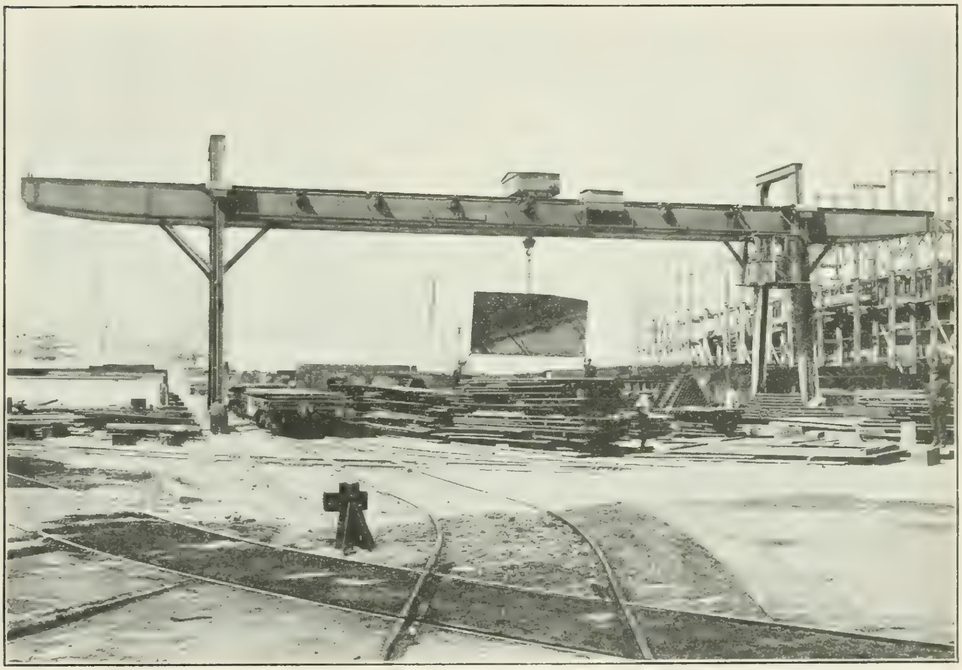


Fig. 9
Gantry Crane

and a larger axle bearing surface can be obtained.

The electric brake, either direct or alternating current, is similar in construction excepting the solenoids. Fig. 7 shows a mechanical load brake of the double disc type with hard bronze wearing surfaces. This brake with the intermediate gears forms a self-contained unit, the parts running in oil. Where direct current is available, dynamic braking is often a desirable feature, eliminating the mechanical load brake, thereby reducing the number of wearing parts. The bottom block is of steel. The hook revolves on ball bearings. The sheaves are bronze bushed and turned to fit the rope. The bottom block is prevented from being hoisted up into the trolley by the application of a limit switch, which cuts off the current from the motor when the hook reaches the dangerous position.

The various types of limit switches are too numerous to mention, apparently having taken the place of the car coupler, of which several hundred types were brought out some 40 years ago, as any railroad master mechanic can tell you. But after all, the best limit switch is the careful, competent, conscientious crane operator.

Careful, not reckless.

Competent in that he knows how.

Conscientious in that he does not neglect his duties.

This kind of man will save dollars in maintenance by keeping the crane properly adjusted, clean and well oiled.

The engineer of maintenance in a large ship building plant called my attention to a crane the other day that had been in service for years—the repairs being but one hoisting rope and one motor bushing, due undoubtedly to the fact that the crane had never been neglected.

Fig. 8 is a picture of the Robbins Dry Dock, Brooklyn. These cranes

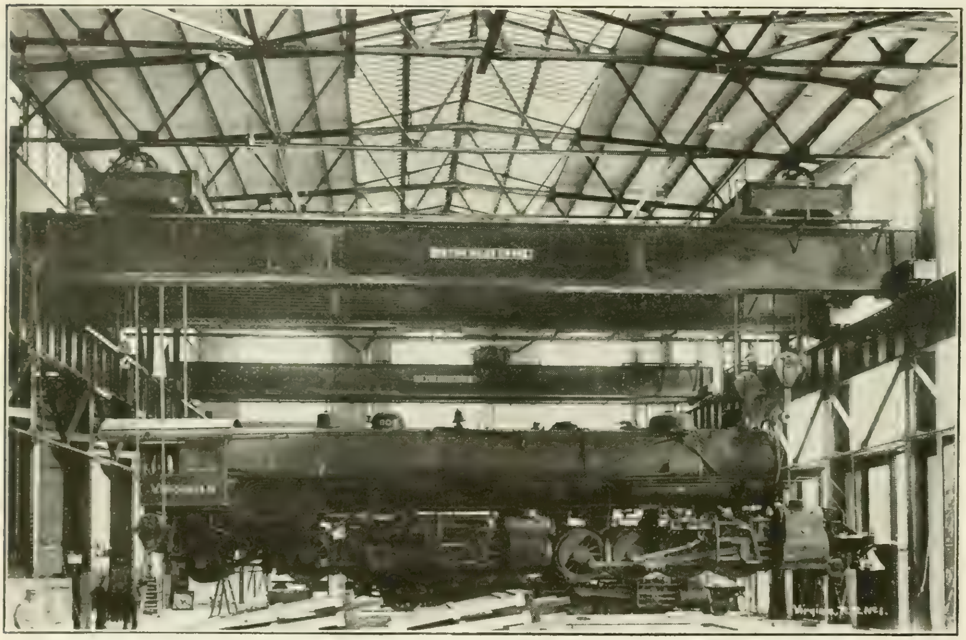


FIG. 10
200-Ton Crane and Load

are operated by alternating current motors. I would call your attention to a novel method this company uses to get variable speed on machine tools with alternating current motors. Each tool is operated by its own independent motor, coupled to a jack shaft with cone pulley, corresponding to the cone pulley on the machine tool.

Fig. 9 shows a gantry crane in the Brooklyn navy yard with 25-foot cantilever extension on each end. The vertical shafts are carried in universal thrust bearings to prevent the gears from getting out of line.

Fig. 10 shows a 540,000-pound locomotive being lifted with a 200-ton crane in the shops of the Virginian Railroad Company. This is a special locomotive crane with 4-point suspension. Ropes lead down to the lifting beams; one for the rear end and one for the front, are fitted with a sling engaging the boiler. The trolley is of the double drum type, one trolley having an auxiliary hoist. This locomotive is advertised as being the most powerful locomotive in the world and is of the type used in hauling coal from the Virginian mountains to the coast for the U. S. Government.

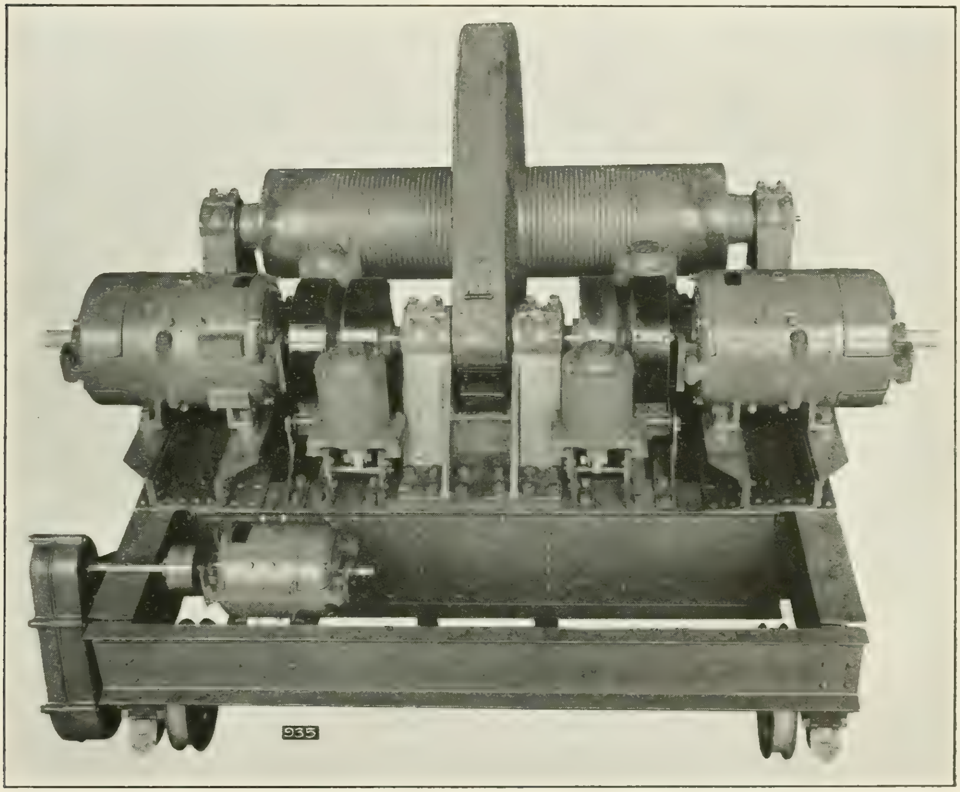


Fig 11
Trolley for Gun-Dipping Crane

Fig. 11 shows a novel trolley for a gun-dipping crane. Note the simplicity of design. The framing is of structural steel: the hoist is operated by two 100-horsepower motors, geared direct to the drum; the gear is enclosed in a welded steel case.

The load is sustained by four electric brakes and controlled by dynamic braking. The steel gear is about 12 feet in diameter. This trolley is of 60,000 pounds capacity and lowers the gun forging into the oil bath under complete control at a speed of 180 feet per minute.

DISCUSSION

E. E. HOLLINGS.—Are the brakes magnetic brakes, or are they friction brakes?

T. E. AUSTIN.—The electric brake is of the solenoid type. The holding power is obtained by the weight of the plunger, which is inside the magnet coil. This plunger is attached to the far end of the brake lever. On the opposite end of the brake lever, adjacent to the fulcrum, is attached a lined steel brake band which nearly surrounds the entire circumference of the turned steel brake wheel, and the holding power is the friction or grip of the band on the wheel.

E. E. HOLLINGS.——Electrically-operated or mechanical brakes?

T. E. AUSTIN.—This brake is electrically operated. The brake plunger is lifted by the magnet. Immediately current is turned on the motor the band is released. Instantly the current is shut off the motor, the plunger falls by gravity and applies the brake.

The mechanical brake (as its name implies) is operated mechanically and depends for its holding power upon the friction of the wearing surfaces, which are bronze discs with circular grooves or insets filled with a plumbago composition not affected by the oil, in addition to the graphite-lined bronze discs. The brake shaft is drilled for central oiling with a stationary oil cup on the end; also the entire brake and intermediate gears run in an oil bath, thereby providing three distinct methods of lubrication to compensate for neglect, and this brake has been known to run for a period of six months without oiling and still remained in good condition.

This, however, was an abnormal case indicating serious neglect and will be avoided in all well regulated plants. A crane is an expensive machine, frequently difficult of access on account of its location; nevertheless it should receive the same care and attention as any mechanical apparatus more favorably placed in this respect. The crane that is kept clean, properly adjusted and well lubricated, will more than compensate for the care in absence of trouble, efficient operation and low maintenance costs.

In lifting the load these parts are held together by the weight of the load acting on an inclined plane and the brake revolves as one piece and no friction occurs. In lowering the load, the motor releases the pressure on the friction discs and plates, the plates being held stationary by a ratchet and two pawls, allowing the load to descend in proportion to the speed of the motor under complete control.

C. O. PALMER.—Is the alternating current reliable for operating the solenoid brakes?

T. E. AUSTIN.—For all practical purposes no differences can be observed in the operation of the crane, whether alternating current or direct current is used.

The regulation of the speed on the alternating current crane has been perfected to such an extent that it can be satisfactorily used in all classes of work, including setting cores, lifting the copes or pouring hot metal in a foundry.

The main difference between the direct current and alternating current crane is that the direct current motor is series wound and the speed of the crane increases with the decrease of the load, while with the alternating current crane the maximum speed is constant. For example, take a 10-ton crane with direct current motors, geared to lift the full load at a speed of 20 feet per minute. The speed of the empty hook would be approximately 40 feet per minute. The regulation of the speed is between zero

and full speed in either case. On the same crane operated by alternating current motors, the maximum speed would be 20 feet per minute with full load or empty hook and the regulation would be between zero and this maximum speed. You will note, therefore, that it is possible to operate the direct current crane with light loads at a higher speed than is the case with alternating current motors. This, however, is seldom required as the maximum speed is rarely used in ordinary operations.

The alternating current crane has one inherent safety feature not found in the crane with direct current motors, in that the motor is built with a pre-determined fixed torque and a heavier load than this maximum torque will handle cannot be lifted, whereas, with the series wound direct current motor there is no limit to the load it will attempt to lift and if excessively overloaded the motor will burn out provided some part of the hoisting mechanism does not fail.

Plant Sanitary Equipment

By W. N. Fitch*

Paper Presented Jan. 22, 1918

Index No. 628.51

The greatest single leak in industry is the shifting of masses of employes from one place to another, and during the last decade leaders of industry have been seeking to find a cause and to eradicate it.

Investigation of the results accomplished by the safety movement demonstrates that there can be no stability of labor unless working conditions are sanitary, agreeable and safe. In order that laborers can go about their work in a contented manner, the physical surroundings must not only be safe, but must be healthful.

The subject under discussion in my paper, "Plant Sanitary Equipment," is a part of the physical surroundings and plays an important part not only in the happiness of the employe, but also in the happiness and health of his family and the community.

In every industry some employes are sufficiently loyal and interested in their work to make it a point to leave their homes or rooming places in time to be on the job at the appointed hour. Here enters the importance of a sufficient shelter, properly warmed and ventilated, provided with seats, where employes can wait and rest comfortably until such time as the doors of the industry open for them to pass in to their regular duties.

Lockers

Upon entering the mill, the employe's next important need in the shape of sanitary equipment is a place to dispose of his or her outer garments. It is my experience that the individual locker system is more satisfactory to the employes, thus giving them a clean, safe place to deposit their outer garments and even making it possible for them to make a complete change, and by using a sensible locking system they are able to control the safety of their property. Of course, it is up to the employes to keep their lockers in a clean condition. However, a system of inspection should be provided to prevent the housing of unnecessaries in lockers.

Lockers should be of metal, substantially constructed, connected in units to the best advantage of the space available. Great care should be taken in selecting the type of locker. It should be of sufficient depth to allow the use of a coat hanger in order that the garments of the employe may be spread out, for on some occasions they will be damp as result of rain, and by spreading them out they will dry much quicker and have a more presentable appearance.

The width of lockers should be sufficient to allow the hanging up of the hat, and any other garments, if the employe should desire to make a complete change. The height should be sufficient to take care of the average length coat. About 54 inches is a generous provision. The top should be slanting to eliminate the collection of dust and prevent their being made a catch-all for various types of material which might fall off and injure the employes, or cause a disorderly appearance. The bottom of the locker should sit up not less than eight inches from the floor for ventilation and cleaning, with an opening in the bottom to allow the possibilities of attaching a ventilating system.

One of the important points is the selection of the latch and lock. The latch should be a type which is operated by the handle pulling outward or upward; no matter how great the strain you put on it, the door comes open. The type of lock should be that which locks in some way the

*Director of Safety and Hygiene, The B. F. Goodrich Co., Akron, O.

latch, along the padlock order, rather than cabinet type.

It may be of interest for you to know that as a result of our investigations, we have adopted a locker unit as follows:

Five lockers collected in a unit, sitting upon a base of four legs, eight inches from the floor, with the height of the front of the locker from the base to the top, five feet; height of the back, five feet six inches; width, ten inches, and the depth, eighteen inches, with a shelf within the same fifty-four inches from the floor, extending nine inches from the back. There is a groove in the shelf on which the coat hanger can be hung. There are two hooks on the opposite side from groove. In the bottom and two inches from the back end is a two-inch hole, the edges of which are turned down for ventilating purposes. Over this opening is a slanting cover, the back of which is five inches from the floor, louvred so as to allow the passage of air. This was installed to protect garments from covering up the ventilator in the bottom or from any material falling into opening, thereby preventing proper ventilation.

On all lockers, the latch is of the type described previously, fastened with a combination pad-lock. We have found that the employes appreciate a locker with the combination padlock, and are very particular about keeping their garments locked up. There is an insert at the top of the locker door for the placing of the name, or check number of the employe.

As to the distribution of lockers in offices or factories, I believe the ideal condition is to have locker rooms connected with both lavaratory and shower bath rooms, the two conveniences named to be equipped with a good quality of fixtures to enable the employes to cleanse themselves with running water, and to this add good liquid soap, together with either or both linen and paper towels, and all conveniences to be placed at or near the entrance of the building. In case such installation is made in some old buildings, conditions may exist to cause such equipment to be placed at such point in these buildings other than the entrance thereto, consistent with the object in view; that is, provide a safe and clean place for the clothing of the employes and a sanitary method of keeping their bodies clean. Under such conditions employes take more pride in their personal appearance, their surroundings and their employment, all of which means success to the employe and employer.

Lavatories

I will not take your time for comparisons, but will briefly describe the method and the equipment of lavatories now in use at the B. F. Goodrich Works, Akron, O.

The lavatories consist of eight-foot units of white enamel steel ware equipped with five goosenecks provided with spray-heads about two inches in diameter, located twenty inches from bottom of lavatory, through which water mixed with steam (for the purpose of warming) flows with some pressure, also between each gooseneck a liquid soap dispenser, tilting style, is attached, filled with a good quality of liquid soap. The lavatory units have no stopper at waste opening in order to assure each user that they may wash in clean running water which has not been used, nor can be used, by anyone else.

In addition to the above, lavatories are furnished with a good quality of paper towels with the ordinary paper towel holder, and in some cases small individual linen towels.

Shower Baths

Shower baths are also equipped with shower heads much larger than those en lavatories, each shower contained in an enclosure for the purpose of privacy, and thorough floor drainage, the floor having a wooden grating as an additional convenience to

the employes. Shower baths are furnished with low white enameled stools, liquid soap dispensers and bath towels of generous size, and all contained in well lighted and well ventilated rooms free from draught, in order to prevent colds and to add to the comfort of the users.

Drinking Water

The all important part of drinking water is its purity. Of course, water must possess other qualities than purity. It must be of a pleasing temperature, as well as attractively clear, and the method of distribution to factory employes must also be considered.

I have in mind one system that is giving satisfaction, composed of an automatically cooled circulating system with founts set at places convenient to the employes. These founts are provided with a spring-operated valve. When the spring is compressed, several streams flow from the inside of a ring toward the center. These streams, upon uniting, form a stream of such quantity as to satisfy the ordinary employes, and quenches their thirst with fine, wholesome water with a pleasing temperature.

Drinking water should be tested daily by competent chemists for impurities.

The founts above described are thoroughly washed daily and therefore present an inviting appearance at all times.

In some of the older plants there is still in existence the crude method of serving water to employes, such as the use of Bristol ware jars, etc. In such cases water of the proper quality and temperature may be served in a reasonably safe manner if jar is provided with a faucet and the individual cup used, whether this cup is of metal or paper. However, extra care must be exercised in this method to prevent the improvident from using another's drinking vessel. The filling of these jars can be done quite safely if the water is furnished from a tank on wheels, the tank being equipped with a pump, which prevents any person handling a pail, and is less likely to catch any flying particles that may be in the atmosphere. I believe that this latter method should be discontinued as soon as the automatic bubbler system can be installed. It is necessary that the jars be washed out thoroughly every day.

The foregoing contains some of my experiences only, and for further information you are referred to the U. S. Public Health Service Bulletin, Vol. 32, issued May 11, 1917.

Cuspidors

Cuspidors are used in many offices and factory rooms to prevent expectorating on floors and in other places, such as spitting being caused by various conditions, the main one being the results of the visible tobacco vice.

The proper cleansing of cuspidors is one of our troubles, because the work itself is not desirable, and again, a real efficient method or machine has not come to our attention. From the engineering profession a method has been adopted at the Goodrich factory, a description of which follows:

Collection and Distribution

A rectangular metal box is used for both collection and distribution, equipped with a cover in four parts (this prevents exposing the contents of carriers to those not in sympathy with the tobacco habit), placed on a four-wheel truck and demountable in order that load, box included, may be promptly removed from truck and a load of clean cuspidors started on its tour of distribution and collection.

Cleaning

Cuspidors are emptied into a digestor composed of a one-fourth-inch screen receptacle placed over a sewer opening, all of which is surrounded by a metal cylinder with foot-operated cover. When the solid matter has filled the screen receptacle it is removed from the cylindrical envelope and an empty clean one replaces it,

the full screen being emptied into a garbage can and covered ready for final disposition at the incinerator.

The cuspidors after being emptied at digestor are passed to a bench provided with racks properly equipped with pegs to set the bowl and covers of cuspidors. These racks are then placed into a machine having a capacity of four racks. This machine is provided with warm water into which has been placed a washing solution, the water being pumped onto contents through rapidly revolving sprays at considerable force. When this washing is done, which requires about one and one-half minutes, the pump is stopped and a douche of steam and hot water is thrown on cuspidors, thereby rinsing them of the washing solution, and which not only thoroughly cleans and disinfects, but also heats the metal of which cuspidors are made, and also drys them upon removing same from the machine. The cuspidors are then removed from the trays and placed in the rectangular box, before mentioned, and are ready again for distribution. Of course, when trays are removed from the machine four more trays replace them, and so on in multiple. The cuspidors used in the Goodrich factory, about 5,000 in number, are made of galvanized metal, about nine inches in diameter, with removable top which is concave with a two-inch opening. All cuspidors are cleaned every day. The method described in the foregoing is the most satisfactory we have seen or heard of.

Toilets

Our experience has taught us the importance of locating toilets on outside exposure for light and ventilation.

In new construction our toilets are installed in towers built especially for elevators, stairs and toilet rooms, located at the most practical point for the convenience of the occupation carried on in the building.

In selecting our equipment, the Engineering and Safety and Hygiene Departments considered the various points as to sanitation and efficiency.

Our standard consists of full length solid porcelain urinals equipped with supply pipes for constantly running water, separated by a screen for privacy; solid porcelain closets with open front type of seats, automatically flushed by seat action; each closet enclosed in a cabinet with door; inside dimensions of the cabinet 48 inches by 32 inches, door having a minimum height from the floor of eighteen inches.

From a sanitary, as well as an economical standpoint, we adopted sheet metal cabinets enameled white. The metal is formed in such shape as to leave practically no openings for the accumulation of dirt. For convenience each toilet room has installed a small or a large lavatory, with flow of water arranged so that employes will not be obliged to touch the control with their hands, also equipped with liquid soap, and individual towels of either linen or paper.

The floors are constructed of concrete pitched to a floor drain. Spigots are supplied for the attaching of hose for flushing out the entire unit. For the sake of cleanliness it is necessary that closets be washed every twenty-four hours.

In conclusion let me emphasize the fact that if the employe and employer are to reap the proper benefits, this equipment must go hand in hand with work rooms properly ventilated and lighted and some painting scheme along practical lines, such as dark green wainscoting, yellow side walls and ceilings white.

All sanitary equipment, as described, means nothing unless you are continuously on the outlook for something to benefit and maintain it.

We are all human, and take more or less commendable pride in looking and feeling well dressed and clean. Cleanliness is truly next to godliness, for, within reasonable limits, the better dressed and cleaner an employe is the greater asset he is to a business.

The plant, then, which has the best conveniences will attract and hold the pick of workmen; for there is not a workman worth while who would not prefer employment in a place where he can wear a good suit of clothes to work, change when he gets there, don a suit of working clothes which have been drying and airing over night, then when he quits for the day shed his working clothes, bathe, wash, don his street attire and step off like a new man, than to work in a dingy, smoky, place where there are no bathing conveniences, and he must go to and from work with the dirt and grime of his occupation on person and clothes.

The Legal Aspect of Safeguarding in Ohio

By E. J. Russert*

Paper Presented Jan. 22, 1918

Index No. 614.8

The legal aspect of safeguarding in Ohio is rather difficult to discuss at this time, therefore, I will attempt to present the aspect or the probable result following proposed rules and regulations which are now being prepared, and in all probability, will be presented to the proper state officials for enforcement in the near future.

First, I will briefly outline existing Statutes in Ohio, to establish by what right and authority such rules and regulations are being prepared, and also by what authority they can, and probably will be enforced. Section 989 of the General Code, that section which created the department of workshops and factories and empowered the Governor to appoint a Chief Inspector of Workshops and Factories, also outlines the duties of the Inspector, to-wit: To inspect sanitary and sewerage conditions, system of heating, lighting and ventilating, means of exit, etc. It also specifies that he or his deputy shall examine belting, shafting, gearing, elevators, drums and machinery. He shall determine whether the locations of same are dangerous to employes, and whether same are properly guarded.

Sections 990, 991 and 992 further outline the duties and authority of the Inspector in respect to bakeries, storehouses, warehouses, etc.

Section 994 establishes the right of any Inspector to enter any building, shop or factory, at any reasonable hour, for the purpose of making an inspection.

Section 996 establishes their authority to order such changes, alterations or installations, which in their opinion, are necessary, and also give them the authority to say when such changes shall be completed.

Section 997 makes it obligatory upon the owner or proprietor to comply with such orders.

I will state that the experiences I have had with department of workshops and factories have been very satisfactory, and that I never have failed to secure extensions or modifications of orders when same were shown to be unreasonable.

The closing section of this statute provided that an appeal could be made and an extension of time gained, and it also provided a good substantial penalty for failure to comply.

It cannot be denied that in face of the foregoing sections any order of the Factory Inspector would become a lawful order or lawful requirement.

Some time early in 1916, the Supreme Court of Ohio rendered a decision in the "Schell vs. Dubois", in which they said that failure to comply with any statute, ordinance or safety order of any municipality constituted negligence *"per se"* and that the person injured could and should recover compensation for damage sustained, unless such injury was due to the gross negligence of injured; the defense of contributory negligence was thereby denied the defendant.

Next, I will briefly present the Workman's Compensation Acts for your consideration. The first act, known as the Voluntary Act of 1911, presented the choice to employers, gave them the option of insuring in the state fund, or self insurance in whatever form they selected, but removed the defenses of fellow servant, contributory negligence and assumption of risk in event they failed to avail themselves of the provisions of the act. For some reason or other, this was not a very popular act and few employers availed themselves of its provisions.

The question of a Compulsory

*The Sharon Steel Hoop Co., Youngstown, O.

Workmen's Compensation Act was presented for the consideration of the electors of our state in the form of a constitutional amendment at the election in 1912 and by their vote the electors decided that Ohio should have a compulsory act to which all employers of labor, employing five or more workmen, must subscribe. The principles of compensation, as outlined in our act, in a great many respects are ideal. There are a great many states of the union which have passed compensation acts, but Ohio has the only act where the employer who has complied with its provisions is not protected against law suits. Section 29 of the Workmen's Compensation Act gives the injured employe the election as to whether he will accept compensation or seek his remedy in suit, and in event he can establish the fact that his injury was the result of a "wilful act" of the employer or his agent or due to the failure to comply with a "lawful requirement", his claim is of good standing, and a sympathetic jury then decides what his compensation shall be and the employer whether he has subscribed to the fund or not must bear all the expense of trial and verdict.

The next subject for your consideration is the Industrial Commission Act, passed by the Legislature March 12, 1913. This act created the Industrial Commission of Ohio and outlined their powers and duties. Section 15 is in part as follows: "Every employer shall furnish employment which shall be safe for employes therein or frequenters thereof and shall furnish safety devices and safeguards, shall adopt and use methods and processes, follow and obey orders, etc." Section 16 in part is as follows: "No employer shall suffer or permit any employe to go or be in any place of employment which is not safe and no such employer shall fail to provide and use safety devices and safeguards or fail to obey and follow orders," etc. Section 21: "The Industrial Commission is vested with the powers and jurisdiction on and after September 1, 1913, to have such jurisdiction and supervision of every employment and place of employment as may be necessary to enforce and administer all laws and lawful orders, requiring such establishments to be safe for the protection of life and health, safety and welfare of every employe or frequenter of every employment and place of employment in the state," etc.

Section 22 establishes the power and duty of the commission: First, to appoint advisors to the commission; second, to administer and enforce the laws of the state; third, to investigate, to declare and prescribe hours of labor, safety devices, safeguards and other means or methods of protection, which are best adapted to render employes of every employment or place of employment safe, to ascertain and fix reasonable standards and prescribe and adopt safety devices and safeguards.

In compliance with the duties prescribed, the commission did appoint such an advisory committee about two years ago, the committee being composed equally of members representing employers and members affiliated with the labor movement, for the purpose of drafting safety rules and regulations and prescribe safety standards.

I have come in contact with all the members of this committee, and I believe their intentions are good. I do not believe that any member would wilfully offer a rule or suggest a standard which he knew would cause a hardship on any employer, but little thought is given to the wording of these rules and instead of aiding the employer to protect his workmen against accident, they actually make him an insured against accident to his employe.

We have on our statute books now 17 safety laws and with the completion of the various codes proposed, we will have as many hundred. The first or

second code completed by this Advisory Committee was the Steel Code, submitted to the Industrial Commission for adoption and adopted, and was sent out as a general order to steel manufacturers. An appeal was made to the Commission for a hearing on the code and at this hearing, a resolution was presented to the Commission. The resolution was to the effect that the code be adopted as a standard for safety inspection to be complied with before inspection. The general order was withdrawn. All this was on account of the indefiniteness of the code. And at a recent meeting in Cleveland, one of the members of this committee offered as a suggestion that the legal make-up of the rules made little or no difference before being submitted to the Commission.

I will state that two lawyers were members of the sub-committee which drafted the steel code and also members of the General Advisory Committee which adopted it and submitted it to the Industrial Commission for approval.

I will not offer any of the suggested rules or regulations, but your attention is called to their value and importance.

If Section 29 of the Workmen's Compensation Act, the section that makes an employer liable at law to the injured, were not a part of the act, I would be out for all the safety measures possible and at present, I am for safety rules, but I want to see those rules right; I want to be sure that when I comply with them I am reasonably certain that I will not be dragged into court, because of such a rule, to defend a personal injury damage suit.

As it now stands with the powers before cited vested in all department of workshops and factories and the Industrial Commission with the expressed duty assigned to the Commission to prescribe safety rules, safeguards and standard, any order of the Chief Inspector or his deputy, or any order, either special or general, issued by the Industrial Commission has the same force and effect as law. And you, who represent manufacturers, are earnestly requested to interest yourselves in the movement. The safety requirements specified in the rules are in most cases excellent, and it was found that the standard offered by several of the codes was less than that maintained by some employers who have made an effort to reduce accidents.

It makes little difference whether the codes are adopted as rules and regulations or as standards for inspection, because if they are adopted as standards for inspection, you will get them sooner or later as a special order with the same force as though they were issued as a general order.

Of course, there is some chance and satisfaction in the thoughts that things may not be as bad as they appear. The Supreme Court in the case against the American Wooden Ware Company, of Toledo, decided there was no ground for action brought to recover damages under the "safe place" provisions of the Industrial Commission Act, and it may be that the same court would decide rules and regulations to be a blanket provision and interpret violation of a "lawful requirement" to mean a violation of a statute, rather than an order of the Commissoin, but I am somewhat fearful, where I consider their decision in the Shell vs. Dubois.

There still remains the questions of the constitutionality of the Industrial Commission Act in so far as the Legislature, having the right to create a commission and delegating to them the power to enact laws, when such power is vested in the Legislature itself alone.

Topography in Relation to Quality of Water in the Design of Public Water Supply

By H. F. Dunham*

Paper Contributed

Index No. 628.1

In the hilly and mountainous parts of our country near the Atlantic coast line including the New England, Middle and some of the Southern States, there are many cities and villages that have had for many years the advantage of public water supplies under gravity pressures.

The general location has been regarded as exceptionally favorable when compared with large areas in the Mississippi valley where hills affording corresponding pressures are not to be easily reached or reached at all. In the ordinary course of events when a New England village found well and spring water insufficient for domestic use and for fire protection a search was made for some convenient brook or ravine at such an elevation above the village that the construction of a dam with moderate pondage would give a water supply for a distribution system under gravity pressure, with early results that were often thought to be satisfactory. The firemen were delighted and the cost of maintenance was small. It is surprising to note the number of water supplies that originated in this way in locations called favorable, and that number is steadily increasing. As the years passed certain difficulties and objections were noted and endured in many instances despite the increase in knowledge pertaining to micro-organisms and their relation to the cause of certain diseases. For instance it was usually found that after heavy showers or long continued rain the water was not clear. In the summer time it was warm. The silt from the brooklet that supplied the reservoir gradually accumulated and to some degree affected the quality of the water. This was increased by the accumulation of leaves in the autumn, also by increased use of fertilizer on cultivated ground and from closer pasturage where it was sometimes observed that flocks and herds found a way to the tributary to the reservoir if not to the reservoir itself. Then at least twice each year and on account of changes in temperature the water in the reservoir "turned over" and the consumers had all of the all-summer tastes and smells supplied at once. This was worse at the fall turning. In the spring the effect was less bad. The quality of the fire protection suffered with increased draft and the slow growth of tubercles in the pipes and there was no simple way to increase the pressure when more pressure was a prime necessity.

Frequently changes were made by increasing the supply from another drainage area and especially by establishing a ground water source and pumping into the storage reservoir. The result of this was the storing of ground water in open instead of closed reservoirs and therefore under bad conditions. Finally as the population increased filters and all of the modern auxiliaries were introduced and the early experience forgotten. But those early experiences are being repeated over and over again in the small villages which appear to be without adequate guides or guards that enable them to escape the troubles incident to small beginnings. They have the State Boards of Health with varying degrees of power to advise or direct yet one can seriously inquire whether a proper degree of attention is given in cases where advice is ex-

*Civil Engineer, New York City.

pected or in other cases where authority is necessary and exercised.

The prairie or flat districts in the middle west where gravity works cannot readily or in any way be established are under physical conditions that often lead more directly to the purveying of good water. First they are obliged in the smaller places to secure water from the ground. In this there is some advantage. Then instead of open earth reservoirs the usual practice is to store water under ground or take it from wells and to use stand-pipes or water towers instead of artificial ponds. Here at least the water is fairly safe from contamination from herds although subject to the turning over process and to many unpleasant smells and flavors. But on the whole it is evident that the absence of mountains has been a favorable condition in the supply of potable water for small water works. It helped to eliminate the temptation to accept or construct unsatisfactory works and to lessen the anxiety of the State Boards.

These observations, largely commonplace rather than novel, are noted here as the result of interest taken by a member of this Society in the progress and welfare of his native village. With a friendly summer resident of the place liberal subscriptions were shared and the town assisted in the installation of a water works. Instead of looking for a good brook the donors after many years of experience in Philadelphia and Cleveland began by searching for good water. Their success is witnessed by the following analysis from the laboratory of the State Board and this source of supply from gravel beds was adopted despite some early adverse counsel from engineers.

Fig. 1

Photograph shows the Completed Dome. Longitude 72° 54'. Latitude 42° 27'.

State Department of Health
Water Analysis.
(Parts per hundred thousand.)
Lab. No. 122609. Mar. 6, 1915.
Subject to Correction.

	Strainer well near left bank of river
Turbidity	None
Sediment	None
Color	None
Residue on Evaporation	5.00
Ammonia Free	.0004
Ammonia Total	.0016
Chlorine	.17
Nitrogen as Nitrates	.0060
Nitrogen as Nitrites	.0000
Hardness	3.4
Iron	.005

the sea had been made and a water wheel set in motion. The idea was that second hand gravitation was better than second grade sanitation. One of the donors had already ornamented the tops of several high mountains in different parts of North and South America with massive domes and the opportunity to add another dome to the list could not be neglected. He was led, however, to be satisfied with an elevation below the summit in this instance and to place the forty-foot diameter dome about 225 feet above the streets of the village as this would give the desirable hydrant pressure which his friend has defined in published tables for other engineers.

FIG. 2

Photograph taken from Dome with Axis of Camera same as axis of Earth. Same Latitude as Fig. 1.

The water supply horizon was about four hundred feet below the village horizon and gravitation results could be expected from the rainfall only after a part of its journey to

The water in this reservoir does not change in quality from some of the causes that affect water in other and neighboring supplies. It remains clear. If it turns over

the revolution is exceedingly moderate. Sunlight growths do not occur and the only chance for objectionable water to find its way into the distribution system is through repairs to the street mains. For some way to avoid this chance in any water supply it might be well to offer a prize. It is a risk, however slight, common to all water works increasing with the size of the distribution system and of the village or city. Thorough flushing after repairs and efforts to sterilize are the approved and practiced method. It is not a perfect method. However carefully it may be carried out, there are cases where physical difficulties cannot be wholly overcome. In this particular it can be compared with accidental failure in processes of filtration. Filtered water is of course subject to the same trouble in its distribution system This is mentioned because it is the one feature that in this case could interfere with the original plan and wish of the donors to provide a perfectly safe and satisfactory supply with little regard to expense. Here as elsewhere any effort is limited by the present state of the art and individual interpretation.

Society Notes

MINUTES OF MEETINGS

January 8, 1918: Regular meeting called to order by President Herron at 8:00 p. m. Present, 95.

Reading of minutes of December 11 and 18 dispensed with.

New members were elected by the Executive Board on January 7 as follows:

Active

E. S. Church
G. E. Day
Edward Everett
L. S. Kuehn
T. H. Niermann
E. H. Reed
H. F. Tielke
W. C. Vogenberger
D. W. Wagar
F. W. Wardwell, Jr.

Junior

Raymond Rolf

President Herron introduced W. L. Ely, who acted as Chairman of the meeting and introduced F. B. Lounsberry, metallurgist, Atlas Crucible Steel Co., Dunkirk, N. Y., who, in the absence of W. F. Abel, as advertised, presented a paper on "Manufacture, Inspection, Etc., of Crucible Steel". Messrs. W. L. Ely, J. H. Herron, R. M. Morgan, F C Parsons, J E. Washburn, joined in the discussion.

Adjourned.

H. M. Wilson, Secretary.

January 15, 1918: Special meeting called to order at 8:20 p. m. by F. B. Wiegand. Present, 75.

Mr. Wiegand introduced H. P. Gage, of the Corning Glass Works, Corning, N. Y., who gave an illustrated paper on "The Adjustment of Automobile Headlights". Mr. Gage showed a number of samples of reflectors and the results of lighting with them. Messrs. R. B. Chillas, G. L. Clark (Grant Motor Car Corporation), W. H. Elliott (Signal Engineer, N. Y. C. R. R., Albany, N. Y.), J. C Lincoln, R M Morgan, R B Perrine and J C. Ulmer joined in the discussion.

Adjourned.

H. M. Wilson, Secretary.

January 22, 1918: Semi-monthly meeting called to order by E. S. Carman at 8:15 p. m. Present, 110.

Mr. Carman introduced W. M. Woltz (Director of Safety, Youngstown Sheet & Tube Co., Youngstown, O.), President of the Ohio Society of Safety Engineers, who introduced the speakers. Mr. R. N. Heist, Health and Safety Department, National Cash Register Co., Dayton, Ohio, gave a review of the safety work being done at the N. C. R. Co., Dayton, Ohio. Mr. W. N. Fitch, in charge of Safety and Hygiene, the B. F. Goodrich Co., Akron, Ohio, gave a paper on "The Design of Good Mechanical Safeguards". Mr. E. J. Russert, The Sharon Steel Hoop Co., Youngstown O., spoke on "The Legal Aspects of Safeguarding in Ohio". Messrs. E. S. Carman, J. C. Gillette, C. O. Palmer, E P Roberts and others joined in the discussion of these papers, which were furnished by the Ohio Society of Safety Engineers

Adjourned.

H. M. Wilson, Secretary.

January 29, 1918: Meeting called to order by E. B. Thomas at 8:15 p. m. Present, 100.

Mr. Thomas introduced J. R. Crouse, who gave a ten-minute talk on the War Savings Stamp work in the Cleveland district. Mr. Thomas also introduced J. B. Clapper, who acted as Chairman for the evening.

Mr. Clapper introduced R. B. Chillas, who gave a paper on "Searchlights", instead of a paper by Prof. F. A. Ray, who, on account of a call to the coast on important work, was unable to be present. Messrs. A. F. Blaser, W. H. Burrage, E. S. Carman, J. E. Clapper, K H Osborn, A. W. Ray and others joined in the discussion.

Adjourned.

H. M. Wilson, Secretary.

February 5, 1918: Special meeting called to order by A. F. Blaser at Case School of Applied Science, Electricity Building, at 8:20 p. m. Present, 50.

Mr. Blaser introduced J. E. Freeman, Engineer, Technical Division, The Portland Cement Association, Chicago, who gave an illustrated lecture on "Concrete Ship Building".

Adjourned.

H. M. Wilson, Secretary.

February 12, 1918: Regular meeting called to order by K. H. Osborn at 8:55 p. m. Present, 110.

Minutes of January 8, 15, 22, 29 and February 5 were approved.

New members were elected by the Executive Board on February 11 as follows:

Active

J. H. Drummond
D. S. Hoon
H. A. Sheets

Mr. Osborn introduced Dr. W. C. Moore, National Carbon Company, as Chairman of the meeting. Dr. Moore introduced J. A. Aupperle, Chief Chemist, Research Department, American Rolling Mills Co., Middletown, Ohio, who presented an illustrated paper on "Manufacture of Iron and Steel and Its Relation to Resistance to Corrosion" Messrs. J. C. Lincoln, A. Meyer, W. C Moore, R. B. Perrine, R. L Squier and R L Williams (American Rolling Mills Co. Cleveland) joined in the discussion

Adjourned.

H. M. Wilson, Secretary.

February 19, 1918: Special meeting called to order at 8:20 by J. C. Lincoln. Present, 100.

Mr. Lincoln introduced J. E. Randall, Consulting Engineer, National Lamp Works, General Electric Company, Cleveland, who presented an illustrated paper on "The Design and Manufacture of Incandescent Electric Lamps".

Adjourned.

H. M. Wilson, Secretary.

February 26, 1918: Semi-monthly meeting. Iron and Steel Section. Called to order at 8:15 by President Herron, who introduced E. S. Carman, Chairman of the Section.

Mr. Carman introduced F. H. Smith, Chief Engineer, The Hydraulic Pressed Steel Company, Cleveland, who gave a blackboard talk on "The Forging of Three-inch Shells".

Adjourned.

H. M. Wilson, Secretary.

March 5, 1918: Special meeting called to order by President Herron at 8:15. Present, 125.

Mr. Herron introduced W. B. Hanlon as Chairman of the meeting. Mr. Hanlon introduced F. A. Ray, Professor of Mining Engineering, Ohio State University, and Consulting Mining Engineer, Columbus, Ohio, who gave an illustrated paper on "Experiences in Russia".

Adjourned.

H. M. Wilson, Secretary.

March 12, 1918: Regular meeting called to order by President Herron at 8:00 p. m. Present, 175.

Reading of minutes of February 12, 19 and 26 and March 5 was dispensed with.

The names of the men elected to membership at the Board Meeting on March 11 follow:

Active

A. E. Buelow, Arturo Fauzon, G. F. Hazelwood, John Schurman.

Junior

J. R. Ikerman.

Transfer—Associate to Active

R. C. Heinmiller.

Announcement was made of the formation of the Association of Ohio Technical Societies and upon motion the Executive Board action in appropriating $10 for membership in the Association was approved.

Upon motion, duly seconded, the following method of choosing a Nominating Committee was approved: That slips be distributed upon which each Active Member be privileged to write the names of seven Active Members whom he would like to see on the Nominating Committee and the seven men receiving the highest number of votes to be declared the Nominating Committee. Messrs. K. H. Osborn, S. E. Roof and Monroe Warner were named by the Chair as tellers. The tellers report showed the election of W. M. Faber, J. C. Gillette, Ed. Linders, Ed. Lindmueller, K. H. Osborn, S. E Roof and Monroe Warner

President Herron introduced E. J. David, Business Manager of "Flying", who gave an illustrated talk on "Airplanes: Present and Future". A short discussion followed.

Adjourned.

H. M. Wilson, Secretary.

March 19, 1918: Special meeting called to order by President Herron at 8:15 p. m. Present, 100.

President Herron introduced M. Luckiesh, Physicist, National Lamp Works, who gave an illustrated talk on "Scientific Aspects of Modern Warfare". Messrs. A. H. Bates, J. C. Gillette, J. C. Lincoln and C. C. Smith joined in the discussion

Adjourned

H. M. Wilson, Secretary.

March 26, 1918: Semi-monthly meeting called to order at 8:20 p. m. by H. N. Wilson. Present, 75.

Mr. Wilson introduced J. B. Clapper, Plant Engineer, The Standard Parts Company, Rim and Tube Division, who gave an illustrated paper on "Electric Butt Welding". Messrs. T. A. Baroo, G. F. Collister, C. C. Coneby, J. C. Lincoln, Ed. Linders, C. O. Palmer, I. E. Waechter and others joined in the discussion.

Adjourned.

H. M. Wilson, Secretary.

April 2, 1918: Special meeting called to order at 8:20 p. m. by F. D. Richards. Present, 55.

Mr. Richards introduced V. C. Hamister, Chemical Engineer, The National Carbon Company, who presented an illustrated paper on "Manufacture and Uses of Carbon Products". Messrs. J. C. Gillette, J. C. Lincoln and F. W. Thomas joined in the discussion.

Adjourned.

H. M. Wilson, Secretary.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUG. 24, 1912.

Of the Journal of the Cleveland Engineering Society, published bi-monthly, at Cleveland, O., for April 1, 1918, state of Ohio, county of Cuyahoga. Before me, a Notary Public in and for the State and county aforesaid, personally appeared G. S. Black, who, having been duly sworn according to law, deposes and says that he is the Business Manager of the Journal of The Cleveland Engineering Society, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of Aug. 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit: 1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, The Cleveland Engineering Society, 310 Chamber of Commerce Bldg., Cleveland. Editor, Publication Committee, E. S. Carman, chairman, 310 Chamber of Commerce Bldg. Managing Editor, None. Business Manager, G. S. Black, 310 Chamber of Commerce Bldg. 2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.) The Cleveland Engineering Society, 310 Chamber of Commerce Bldg., composed of 1200 members. President, J. H. Herron, 2041 E. 3d street, Cleveland, O.; vice president, E. B. Thomas, 619 Guardian Bldg., Cleveland, O.; secretary, H. M. Wilson, 1250 Rockefeller Bldg., Cleveland, O.; treasurer, C. E. Drayer, 512 Columbia Bldg., Cleveland, O. 3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None. 4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him. 5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is. (This information is required from daily publications only.)

G. S. Black, Business Manager.

Sworn to and subscribed before me this 22nd day of March, 1918.

(Seal) A. J. Miller, Notary Public.

(My commission expires April 26, 1918.)

JOURNAL OF
The Cleveland Engineering Society

Concrete Ships and Barges—A War Measure

By J. E. Freeman*

Paper Presented Feb. 5, 1918.

Index No. 623.84

Since our entrance into the war, it has become increasingly evident that ships and more ships is the need of the hour, their speedy construction in large numbers is a vital factor in our war program—a military necessity. Over our lines of communication must travel a constant stream of supplies for our forces in the field and our allies.

Steel and wood vessels under construction in countless yards, ships transferred from coastwise and Great Lakes service, are yet not sufficient to answer the demand. If another method of shipbuilding can be developed to augment the tonnage under construction and with all possible speed it will help to solve the problem, and for this purpose reinforced concrete is now being considered.

Transportation of government supplies and material to the seacoast is taxing heavily the resources of the railroads. Utilization of present inland waterways as well as our main highways assumes increasing importance. River and canal transportation must be developed, harbor facilities increased. For this purpose fleets of barges and lighters must be built, some of which are big enough and staunch enough for coastwise or Great Lakes traffic under their own power or in tow, to take the place of ships transferred to other service. Lighters are needed to aid in transferring supplies at seacoast terminals.

In view of this it is only good judgment to reckon with the possibilities of reinforced concrete, especially since concrete materials are readily available while the steel needed and labor required will offer little interference with the government's requirements for other war purposes. The possibility of greater speed in construction is also an important factor.

Concrete barges have already proved their usefulness on the Welland Canal and on Chesapeake Bay. They are being used in increasing numbers on waterways in England and in France. It is reported that such barges are also in use on the English Channel for transporting military supplies.

I do not claim to be versed in the design of ships; that has been for many years the field of the naval architect and marine engineer. Barges and scows for use on canals, rivers and other reasonably quiet waters may not necessarily involve much knowledge of naval architecture, but in the barges and ships for coastwise, Great Lake or ocean service, special problems are presented with regard to strains to which vessels are subjected in a seaway and in developing proper lines for desired speed, draft, etc. To construct such vessels in concrete requires both the skill of the concrete engineer and the naval architect. The concrete ship construction now underway in this country is largely experimental though assisted by experience gained in the design of steel and wood ships, but as has been the case in other applications of concrete to new uses, experience with these first

*Engineer Technical Division, Portland Cement Association, Chicago, Ill.

vessels will provide data to improve and clarify present ideas and to develop efficient methods of design and construction. Those who have thus far worked out designs for concrete ships have done so more or less independently and up to the present have not published the data and calculations upon which their designs are based, but the government is reported to be studying the problem also, and we may expect interesting and valuable developments before many months.

This present discussion of concrete ships and barges must then of necessity be rather general. I wish tc review briefly what has been done in past years and then discuss some of the interesting work under way at the present time.

Singularly enough, one of the first uses of what would today be called reinforced concrete was in boat building, a rowboat built in 1849, by M. Lambot, of Carces, France, thus making the starting point not only of concrete boat building but also of modern reinforced concrete construction. This boat was exhibited by its builder at a world's fair in Paris in 1855 and was apparently in excellent condition as late as 1903.

In 1899 Carlo Gabellini, of Rome, began the construction of concrete barges and scows in Italy, and in 1905 a 150-ton barge was constructed for the city of Civita Vecchia. Later another barge was built for the use of the Italian navy at Spezzia which, before acceptance, was put to the severe test of being driven against piling and afterward being rammed by a steel towboat.

Briefly, the Gabellini method was as follows: Reinforcement of round rods was first placed for the keel and ribs, covered on the outside with ¼inch wire mesh to which a 1-inch coat of cement mortar was applied by hand. Next, a somewhat thinner coat of mortar was placed on the inside, following which, forms for the ribs and keel were set and concrete deposited for these sections. The ribs, 2 inches wide, ran both longitudinally and transversely, forming pockets about 10 inches deep. For some barges, ⅛-inch wire mesh was placed over these ribs and plastered with a thin coat of mortar, a coarser wire mesh pressed into the soft mortar and the whole surface plastered over. Concrete bulk-heads and wooden fenders and gunwales finished the craft. Up to 1912 about 80 vessels had been constructed by this concern.

Beginning as early as 1887 small concrete barges of 11 tons capacity were built successfully by the Fabrieck van Cement-Ijzer Werken, in Holland, followed later by larger craft.

In Germany, a 220-ton concrete freighter was built in 1909. The major portion of the hull had parallel sides, but was so shaped that the lines were fairly good and water resistance was decreased below that of a rectangular barge. This vessel also had watertight bulkheads.

In 1912 a reinforced concrete scow or pontoon was built by the Yorkshire Hennebique Contracting Co., Ltd., of Leeds, for the Manchester Ship Canal Co., in accordance with the requirements of the company's engineers. The craft is 100 feet by 28 feet by 8 feet 6 inches deep from main deck to keel, drawing about 6 feet 6 inches when loaded to capacity (about 224 tons). It carries centrifugal pumps, steam winches, engines, boiler and coal supply.

Construction of the hull is a series of watertight compartments. The compartment containing the boiler plant has a 4-inch floor and heavy beams supporting coal bunkers and boilers, but otherwise the general construction is light; the outer skin of the hull is only 3 inches thick. All watertight compartments were carefully tested by filling them with water. The scow has been in almost constant service since construction with small expense for repairs.

In 1910 we find the building of concrete barges undertaken on this side of the Atlantic. On the Welland Canal, the "Pioneer", an 80-foot barge, was built for maintenance work. Design and construction were carried out under the supervision of J. L. Weller, St. Catherines, Ontario, engineer in charge of the canal work. The barge has a beam of 24 feet and depth of 7 feet with rounded bow and square stern. The hull was divided into eight compartments by longitudinal and cross bulkheads, double hatchways at stern and openings through the cross bulkheads giving access to all parts. Two 6 by 8-inch oak wales serve as fenders. The deck, bottom, sides and bulkheads are each 2½ inches thick, reinforced in two directions with ¼-inch steel wire and strengthened by the bulkheads and by beams and posts of reinforced concrete about 6 by 8 inches in size. The barge draws 2 feet 8 inches light (130 tons displacement) and when loaded to capacity (200 tons) has a draft of 6 feet.

From 1910 to the present this barge has been in almost constant service with no maintenance charges and is still in excellent condition. At times she has been loaded with 10-ton carloads of rubble stone dumped from a height of 12 to 15 feet directly onto the 2½-inch deck, the full load starting at one end.

On the Panama Canal three concrete barges 64 feet long, 24 feet beam and 5 feet 8 inches deep were built in 1910 to carry dredging pumps forming part of a plant used for hydraulic excavation at the site of Miraflores locks and were launched in the spring and summer of that year. Reinforced concrete was used because it was impossible to obtain skilled labor and suitable material for the construction of steel or wood barges within the time required.

The walls and bottom were made 2½ inches thick, two 3-inch bulkheads extending from bow to stern making three compartments. Longitudinal beams at top and bottom of bulkheads and side walls, with posts at 10-foot intervals, cross connected at posts by beams with knee braces, comprise the general framing plan. The shell was a 1:2 mortar plaster on the steel skeleton of rods and mesh. Interior members were 1:2:4 concrete cast in forms. The draft was 3 feet 5 inches with total load of about 140 tons.

Following this work, in 1913 and 1916 a number of reinforced concrete pontoons were built at Panama to serve as landing stages for boats up to 65 feet in length, and have been in regular use since. These pontoons are 120 feet long, 28 feet wide and 8 feet deep.

While harbor engineer of Baltimore, Oscar F. Lackey developed a system of concrete barge construction which was first usd in 1909, to build a landing stage for small boats and then in 1912 was applied to building a concrete scow for the Arundel Sand & Gravel Co., of that city. This craft has a length 113 feet, a breadth of 29 feet and a depth of 10 feet 6 inches. The scow is used for transporting sand and gravel, or coal.

Four longitudinal bulkheads and five cross bulkheads divided the craft into 20 watertight compartments. The walls were supported by a series of vertical and horizontal beams, the slabs varying from 3 inches to 5 inches in thickness, reinforced with plain bars running in both directions. The hull was built between forms and a very rich concrete mixture was used.

To aid towing the sides were rounded on about a 6-foot radius and worked into sloping ends which were carried back much farther than in the ordinary scow.

The scow has been in daily use ever since construction, is perfectly watertight and has withstood the roughest kind of handling, requiring no pumping out and apparently accumulating no barnacles or sea growth of any kind. Light, the scow draws 4 feet 3 inches and when loaded to 500 tons, its capacity, has 1 foot freeboard.

The rounded sides and ends developed some undesirable features under load in a high sea or strong wind and in berthing. Consequently in the two scows that were built in 1913 and 1915 respectively, the design was more along the lines of the ordinary wood scow. These scows were also cheaper to construct, the form work being less expensive and placing of reinforcement easier. In the second, five longitudinal and five cross bulkheads were used, and a combination of bars and expanded metal used for reinforcement. In the third scow an intermediate deck was introduced. The difficulties found in towing the first scow were eliminated and the draft reduced to 3 feet 10 inches. This was but slightly in excess of a timber scow of the same capacity, but the concrete scow towed as easily when new, according to Mr. Lackey, and more easily than the other after a few months service because of the lack of formation on the bottom.

One of these scows is used by the Raymond Concrete Pile Co., at Baltimore, a letter from whom last July stated that this scow had been very satisfactory in every respect and there had not been a dollar's worth of repairs since the scow was placed in commission.

Considering that these scows are watertight, do not require hauling, scraping, caulking, painting or maintenance other than repair to wooden fender system, and crediting the cost of time that would otherwise be lost in making such repairs, the concrete scow becomes a decidedly interesting proposition.

England and France have seen the possibilities of barges and self-propelled lighters of concrete. Last spring an English periodical mentioned a French company formed for the purpose of building sea-going concrete lighters; later, pictures were shown of concrete boats under construction on the Paris Ship Canal. The Under Secretary for Sea Transportation and Merchant Marine in France was recently quoted as saying that very interesting experiments had been made with two concrete lighters in service. This has doubtless led to the building of more craft near Bordeaux, also twin-screw vessels at Ivy-on-Seine, of which recent press photographs give a general idea though details are lacking. An English paper reports orders on hand from the French government for several hundred concrete barges. Several English firms have begun the building of motor-driven barges of concrete and more recently a concrete shipbuilding company has arranged for yards at Dundee in Scotland.

Jas. Pollock & Sons Co., a London firm of naval architects and engineers, has drawn plans for a fleet of small coasting vessels of reinforced concrete, the first vessel laid down having a length of 92 feet, beam of 19 feet and depth of 10 feet. Power is obtained from a 120-horsepower oil motor. In coasting vessels which need not make over 8 miles an hour, the use of straight lines would not necessarily be a handicap and these concrete vessels have therefore been designed with such lines wherever possible to reduce form work, simplify bending and placing of reinforcement, etc. This firm is now drawing plans for larger vessels of 500 to 1500 tons cargo capacity.

A letter just received from a former Chicago engineer, now in England, advises that he has recently designed a number of barges and seagoing vessels of reinforced concrete and is at present interested in the building of 10 such seagoing barges of 1,000 tons capacity. It was recently stated by the First Lord of the Admiralty that ferro-concrete barges up to 1,000 tons were being built in Great Britain which possibly refers to this same work.

The first Spanish reinforced concrete cargo boat will be launched shortly, being built at Barcelona. The length is about 110 feet, beam 23 feet

and depth 11¼ feet. Power will be supplied by a 120-horsepower Diesel engine and in addition sails will be fitted to the vessel. Much larger vessels up to 1,500 tons load are in progress.

Yet this work in shipbuilding is not entirely new, for Norwegian and Danish firms have already built and launched several concrete motor barges and ships of 200 tons capacity and now have larger craft under construction.

the Norwegian navy. The structure consisted mainly of keelson and ribs of reinforced concrete with a thin shell of concrete plastered on expanded metal or cast around rods.

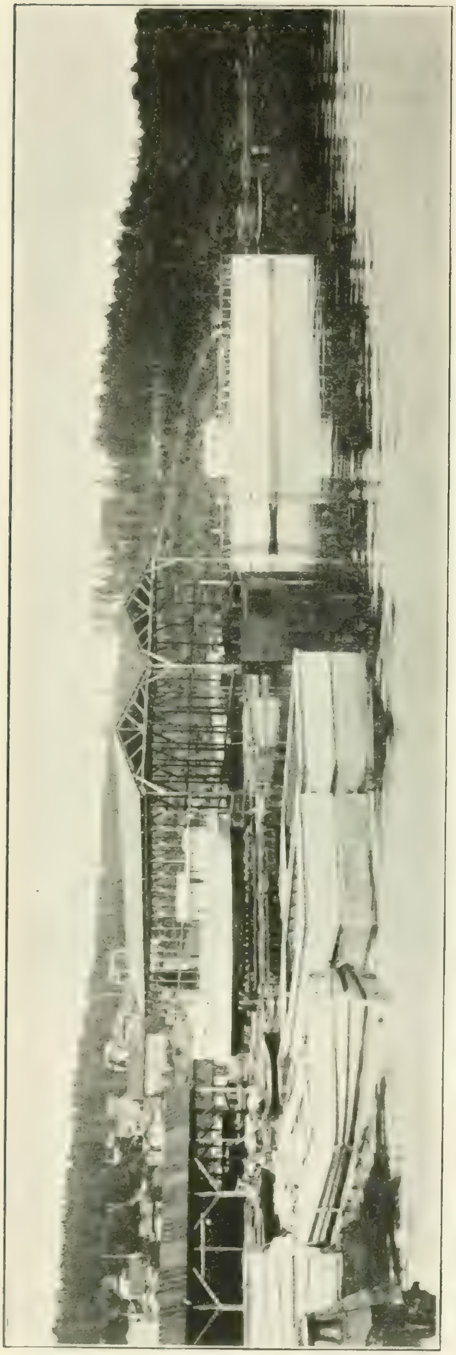
This method of construction has been applied to the first seagoing concrete ship, the "Namsenfjord", launched last summer, given a high rating by Lloyds and now in service for coastwise traffic. This vessel has a cargo capacity of 200 tons on 9½-foot draft and is driven by a Bolinder

Launching of the 200-Ton Motor Ship "Namsenfjord" at Fougner Yard, Together with View of 100-Ton Floating Dry Dock

The Fougner Steel Concrete Shipbuilding Company, which has a plant at Moss, established in 1916, has built some 20 reinforced concrete lighters and tow boats following successful experiments made by Mr. Nic. K. Fougner with a 50-ton concrete lighter at Manila in 1914. These lighters carry from 100 to 200 tons, the later types having more the barge shape. Some are in use along the Norwegian coast and others have been bought by

crude oil engine of 80 horsepower, giving a speed of about 7½ miles an hour. The length is 84 feet, beam 24 feet, moulded depth 11½ feet. Larger ships of 600 to 1,600 tons are now building, but their general design is much the same as that of the "Namsenfjord", briefly described as follows:

There is a keelson of reinforced concrete with cross frames every 4 feet, the frames being continuous



YARD OF THE FOUGNER STEEL-CONCRETE SHIPBUILDING CO., MOSS, NORWAY—200-TON MOTOR SHIP "NAMSENFJORD" READY FOR LAUNCHING—100-TON DRY DOCK AT RIGHT

along sides and bottom and tied to the keel by the rod reinforcing. Particular attention is paid to continuity of reinforcement for these frames, and knee braces are provided at corners of the hull. The skin is 3 inches thick reinforced with mesh and having a longitudinal beam at the outer corners of the hull. Concrete filled pipes are used for center posts at intervals. The hull is divided into watertight compartments by transverse bulkheads of concrete reinforced with metal lath. The cabin is of wood and wood fenders are provided.

In building the hull, the bottom is cast in forms up to the top of the longitudinal hull beam previously mentioned. For the side of this size vessel the reinforcement and metal lath is set up for the total height and concrete deposited between the two sets of lath which act as a form; the outside and inside surfaces are then plastered. For larger boats this procedure is altered, using shorter heights of lath or casting the main frames in forms. Care is taken to make the construction continuous, however, so that no joints are left in surfaces exposed to water.

In the earlier craft a 1:1½:2 or 1:1½:2½ concrete was used with ½-inch maximum size aggregates, but later developments showed a 1:2 mixture with ¼-inch material worked better around the reinforcement.

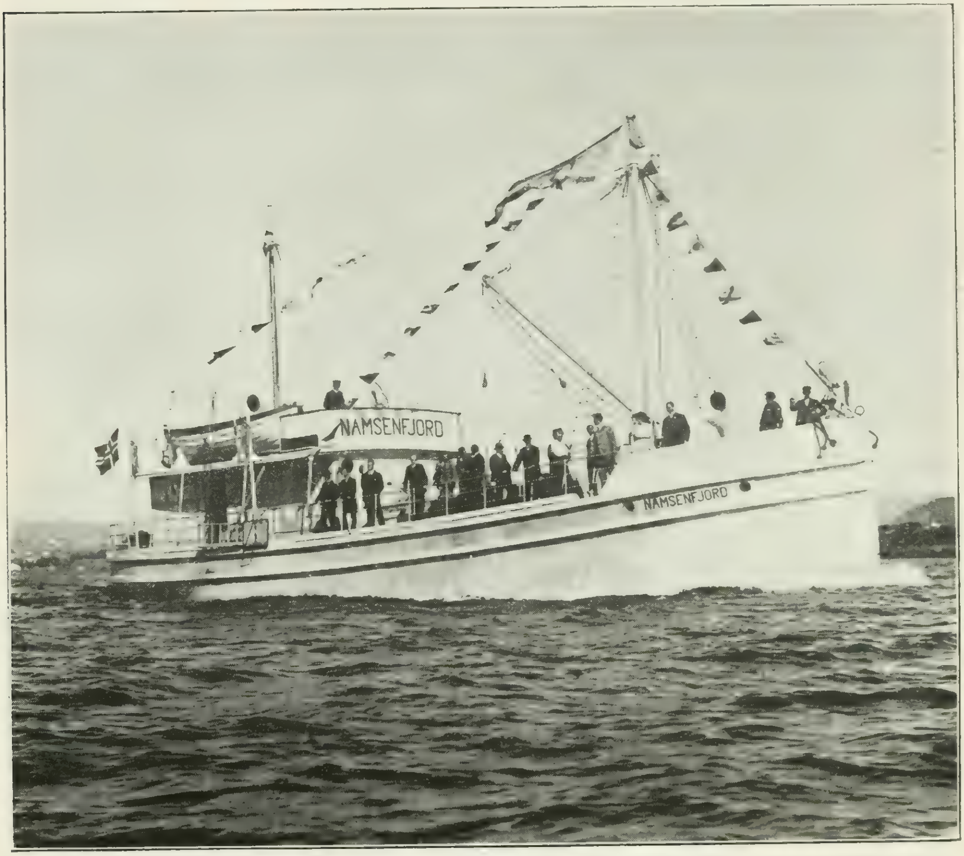
The company has a contract for a 4,000-ton ore carrier 250 by 40 by 19½ feet equipped with two 300-horsepower Diesel engines and only awaits authorization by the Norwegian Marine Registry before proceeding with the construction. It has also constructed a tugboat and a floating drydock of concrete, the first of its kind, with a lifting capacity of about 100 tons which suggests another field for development in the present emergency.

The dock is 80 feet long, 38 feet wide and 20 feet high, with a sill 4½ feet thick and side walls 6½ feet wide at the bottom. There are nine watertight compartments. The dock ac-

commodates a vessel 75 feet by 25 feet and is equipped with an electrically operated centrifugal pump by means of which a 100-ton load can be lifted from the water in one hour. The dock was built for a Christiana firm of yacht builders. The Fougner Company has plans for larger docks up to 15,000 tons capacity.

pounds). The displacement of a ship is the weight of water she displaces and covers the weight of the ship itself plus the dead weight.

Another Norwegian company actively engaged in concrete boat building is the Porsgrund Cement Construction Works, at Porsgrund. After the construction of a pontoon in



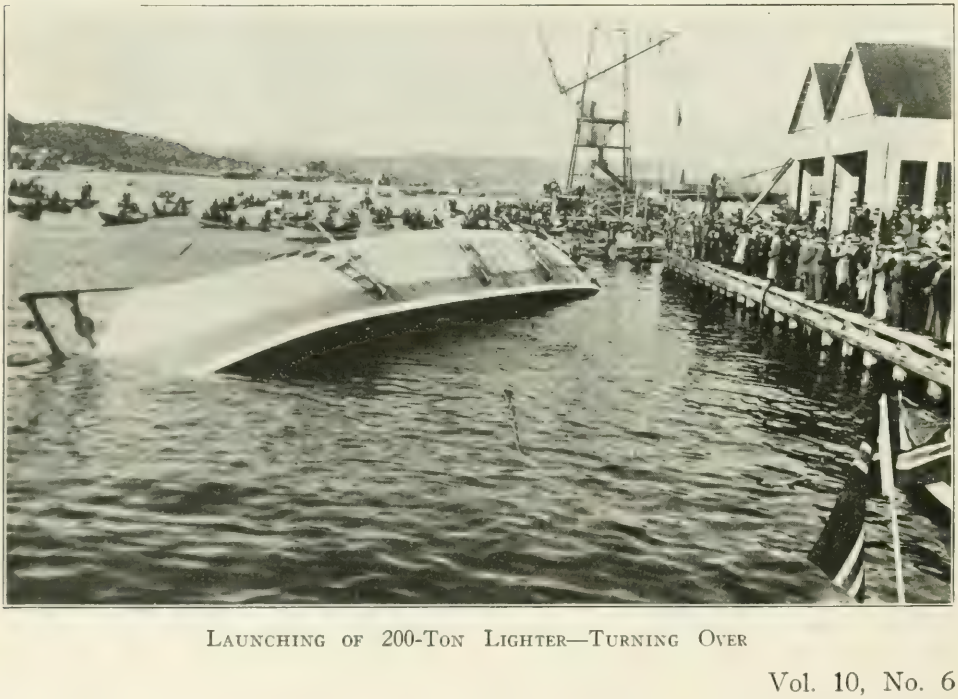
Motor Ship "Namsenfjord" on Trial Trip

The ships built according to the Fougner system have a ratio of dead weight to displacement from 12 per cent to 15 per cent less than for steel ships, that is, their displacement is greater for the same cargo carrying capacity.

By dead weight is meant the cargo carrying capacity expressed in tons, usually in terms of long tons (2240

1913, experiments were begun with a view to simplifying the form-work and construction methods, as a result of which it was determined to build the boats upside down and launch them in that position, an ingenious arrangement of inner airtight compartments and air-valves making the craft practically self-righting. After successful experiments with a 9-foot

LAUNCHING OF 200-TON LIGHTER UPSIDE DOWN—PORSGRUND CEMENT CASTING WORKS PORSGRUND, NORWAY



LAUNCHING OF 200-TON LIGHTER—TURNING OVER

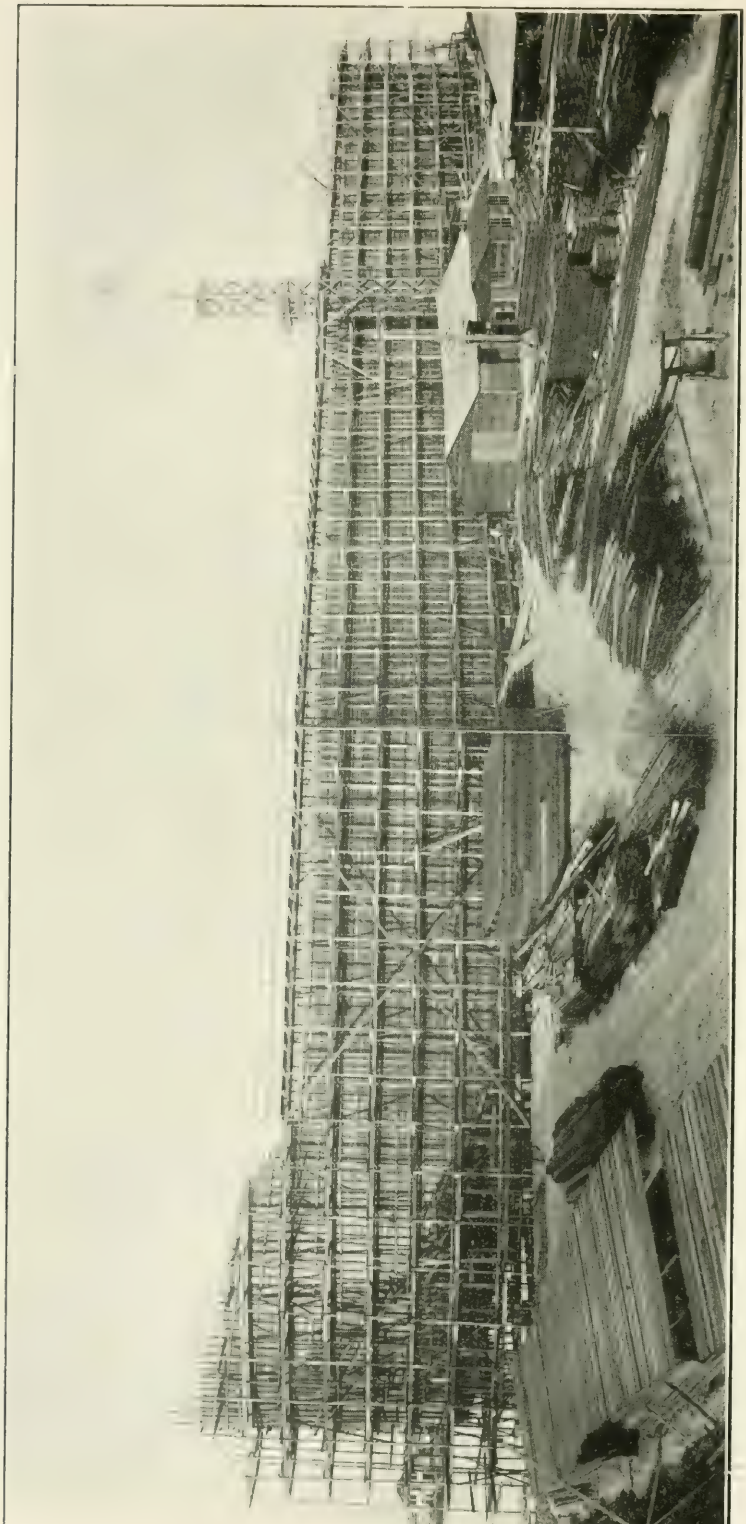
model a 200-ton barge was built and launched last summer. The barge has a length of 98½ feet, beam 19½ feet and moulded depth ranging from 9 feet at center to about 10½ feet at bow and stern. It will be equipped with a 70-horsepower motor. Other lighters are in process of construction having capacities of 600 to 1,000 tons. The general design follows that of a framed steel ship.

Launching of 200-Ton Lighter—Righted

The righting of the 200-ton barge took place in about 20 minutes. The principle may be briefly described as follows: The inner mold is divided into compartments; when the vessel enters the water the air gradually escapes from the middle and upper two compartments through vent pipes, and the vessel losing buoyancy gradually sinks to a point of maximum submergence. The lower side compartments never being flooded the vessel is in a state of unstable equilibrium, the center of gravity being considerably higher than the center of buoyancy. If the vessel now heels slightly to one side or the other a couple is formed the moment of which tends to turn the vessel on a longitudinal axis until the vessel is righted and floats in correct position. The flooded compartments are then pumped out and the molds removed to be used again for a similar vessel.

Progress in concrete shipbuilding has been made in Denmark also; one firm is reported to have several types from 300 to 1,000 tons deadweight approved and classified by the Bureau Veritas for overseas service. The work has been developed so far that official rules have been laid down for design applying to the construction of flat bottomed vessels of reinforced concrete.

The main requirements reported are that the bottom and sides must be at least 7 cm. (2.8 inches) thick. Flat surfaces less than 8 cm. (3.2 inches) thick are to be considered as simply supported unless so reinfoced as to be capable of withstanding bending moments in both directions.



CONCRETE SHIP UNDER CONSTRUCTION AT REDWOOD CITY, CALIF.

The stress in steel must not exceed 8 tons (18,000 pounds) per square inch. The compressive stress on the concrete must not be over 800 pounds per square inch. When the calculated shear stress on the concrete exceeds one-tenth of the compressive stress provision must be made for taking it wholly on the metal reinforcement. Further data is given in recent issues of several marine journals.

At Montreal, the construction of a 126-foot ship was started early in September by the Atlas Construction Company, Ltd., and the ship launched in November. The vessel has a beam of 22½ feet, a depth of 12½ feet, structural steel ribs encased in concrete, and a shell carrying from 3 to 6 inches in thickness. The steel ribs are spaced about 27 inches apart and are 5 inches deep at the top and 14 inches at the base. Before plans were prepared, tests on model ship beams were made to ascertain the resistance of concrete to some of the strains encountered in ship design.

The vessel is of the single screw type making about 8 miles per hour. She has a capacity of 350 tons and draws about 6 feet light. Fifty tons of reinforcing steel were used in construction. The concrete, I understand, is practically a mortar, about 1:1½:1 with small gravel. It was placed between forms, construction being carried on as continuously as possible. The plans were prepared by C. M. Morssen, Civil Engineer, Montreal, and Prof. Ernest Brown, of McGill University.

At Redwood City, near San Francisco, construction was started last summer by the San Francisco Shipbuilding Co. on a 330-foot ship of about 5,000 tons deadweight and is progressing favorably, although it is difficult to secure any details. The vessel has a beam of 44½ feet and moulded depth of 30 feet. She is to be fitted with Scotch boilers and triple expansion reciprocating engines of 1750 horsepower, giving a speed of 10 knots. Fuel oil tankage is to be provided sufficient for 30 days' steaming. Cross frames are placed about 4 feet apart and interior columns, supporting a 3½-inch deck, about 16 feet on centers. The bottom is about 5 inches thick, decreasing to 4 inches at the deck. Both rods and wire mesh are used for reinforcement, diagonal reinforcement being used in the shell. The exact proportions of the concrete mixture are not known, nor are further details available as to design, etc.

Although several firms in New York City have been developing plans for barges, the first constuction work of this character was begun by the Louis L. Brown Company last October: a 700-ton deck scow of length 112 feet, beam 33 feet, depth 10 feet and light draft 3 feet 4 inches.

The frame of the barge consists of reinforced concrete members supporting a thin concrete shell reinforced with wire mesh. Rail, bulkheads and deckhouse are of concrete; wooden fenders will be used. Concrete is placed by means of a cement gun.

Construction of a 500-ton scow will be started shortly at Vancouver, B. C., the plans having been prepared by the Taylor Engineering Company of that city. This has an overall length of 107 feet, beam of 32 feet and depth of 9½ feet. It will draw 3½ feet light and 8½ feet when loaded to capacity. The truss method of framing is of interest. The same company is now designing a 1,200-ton well deck scow. A New Orleans sand and gravel company is now building a dock barge 130 feet by 30 feet by 7½ feet deep, of about 550 tons deadweight.

A Joint Committee of the American Concrete Institute and the Portland Cement Association has been investigating this subject and recently prepared a report covering points to be considered in designing concrete vessels and submitting a tentative de-

sign for a 2,000-ton seagoing barge of the following dimensions:

	Ft.	In.
Length overall	227	6
Length between perpendiculars	220	0
Beam	42	0
Depth	23	0
Loaded draft	18	0

The displacement was estimated to be 3,675 tons on an 18-foot draft. The vessel is divided into five compartments, by transverse bulkheads, the three center compartments being for cargo and the other two for tanks and ballast.

In designing, the criterion followed was a steel ship designed according to Lloyd's rules, and practically equivalent strength provided in reinforced concrete. A concrete of 1:1:2 mixture with carefully selected sand and selected gravel (about ½-inch size) was decided upon and considered to develop an ultimate crushing strength of at least 3,000 pounds per square inch, allowing a maximum stress in concrete of 1,000 pounds per square inch.

The spacing of the frames is 4 feet and the thickness of shell 4 inches on the sides and 5 inches on the bottom. Two lines of reinforcement are provided. The deck is 3 inches between hatches and along the lines of the hatches and 5 inches thick outside these lines.

An estimate of quantities gave the following:

Concrete, 731 cubic yards.

Steel, 482,000 pounds.

Flooring for hold, 30,000 feet, board measure.

Oak timber (fender rail), 15,000 feet.

The total weight of ship was estimated to be 1,647 tons and the carrying capacity for 18-foot draft 2,028 tons. The cost of hull per ton deadweight was estimated at $63.00, best available figures indicating a cost of steel hull of the same character of $90 to $120 per ton and the cost of a wooden hull $70 to $100.

From the report of the Joint Committee the following is quoted in regard to points connected with the design of concrete vessels:

"It is apparent that the efficiency of a ship as a cargo carrier depends upon the relationship between deadweight and displacement. Expressed in terms of per cent, in the average cargo ship built of steel, the deadweight is from 70 to 75 per cent of the displacement, taking into account as weight of ship all spars, fittings, deck houses, anchors and chains, auxiliary engines and tanks, but not boilers, engines or coal. In a wooden ship, the deadweight is from 60 to 65 per cent of the displacement. It is quite evident that from the difference in weight of materials, it will be difficult to design a ship of concrete that will give a relationship between dead weight and displacement approaching that of steel. However, if ships are to be built of concrete for commercial use, the weight of the ship must be such as to provide a reasonable deadweight or cargo capacity for the displacement.

The stresses in the transverse members of a ship are, in still water, functions of the draft and the stiffness, and may be computed by mathematical processes, although the computations are long and laborious. When the material is reinforced concrete the problem becomes much more complicated. Experience has shown, however, that numerous elements other than draft affect the transverse strength of a ship, such as the effect of rolling in a seaway, impact with docks or other ships, and stresses incident to going into drydock. The transverse members of cargo ships of today are, therefore, not designed to withstand computed stresses, but are designed in accordance with various rules which embody the result of long experience in the construction and use of ships. It should be noted in this connection that granting of insurance depends on compliance with these rules.

Steel ships are of two different types: (a) Framed ships, in which transverse ribs or frames are spaced from 18 to 24 inches on centers, the plating being riveted to these ribs without intermediate longitudinal members, excepting in the bottom; and (b) longitudinally framed ships (Isherwood) in which heavy frames are spaced from 10 to 15 feet on centers, with intermediate longitudinals to which the plating is riveted.

From a comparison with the ordinary steel ship design, it would appear to be not difficult to design transverse members of reinforced concrete of equivalent strength to steel members, the question of strength only being considered.

A ship must be able to meet conditions which are unlike any to which land structures are subjected.

In determining the longitudinal strength of a ship, it is customary to assume two conditions. Under the first condition, the ship is assumed to be suspended between two wave crests, the length between crests being equal to the length of the ship between perpendiculars, the height of the wave being equal to one-twentieth of that length. In this case, the ship as a whole is acting as a simple beam supported at the ends. This condition is termed "sagging". Under the second condition, the ship is assumed to be supported amidships on one crest of the same wave. Under this condition, the ship as a whole acts as a cantilever. This condition is termed "hogging". It is apparent, therefore, that when a ship is riding the waves both the deck and the bottom of the ship will be required to withstand tensile and compressive stresses alternately—the maximum tensile stress following the maximum compressive stress at very short intervals. In a steel ship the entire cross sectional area of the 'midship section acts to resist these stresses, taking into account, in determining the moment of inertia, all of the continuous members such as continuous scantlings and deck, side and bottom plates. In the concrete ships, equivalent strength must be provided. In the case of the concrete ship, however, only the steel reinforcement can be relied upon to take tensile stresses. The concrete assisted by the steel will take the compressive stresses.

There is an almost unanimous opinion among naval architects and seafaring men generally that a concrete ship will be so inelastic that she will tear herself to pieces in a sea. While it is doubtless true that in a concrete ship there will not be the same readjustment of stresses as in a steel ship when subject to the action of a heavy sea, experience with reinforced concrete structures generally has shown that such structures have considerable elasticity and there is ample reason for the hope that reinforced concrete will prove a suitable material for shipbuilding purposes."

As to the effect of sea water on concrete, recent investigations by the Bureau of Standards as reported by Messrs. Wig and Ferguson throw new light on the subject and point out remedies. The results of their investigation tend to show that inferior concrete or concrete of which the surface skin has been impaired, suffers serious effects when in contact with sea water. However, there is every reason to feel assured that the care needed in the selection and proportioning of materials and in mixing and placing and finishing concrete for concrete shipbuilding will provide the proper remedy.

With regard to the protection afforded the reinforcing steel the investigations of the Bureau of Standards show that Portland cement itself is durable in sea water, which suggests that the rich mixture of concrete used in concrete ships, if properly deposited around the reinforcement, will provide the requisite protective coating.

Besides the work now under way which has been mentioned, plans are nearing completion for the construction of other vessels on the Gulf and

Southern Atlantic coasts so that in the course of six months there should be much more detailed information available on the subject. The art of concrete shipbuilding might be said to hold the position occupied by reinforced concrete 15 years ago, but the knowledge gained during these years is helping to solve the present problems, and we may be sure of a rapid development in this hitherto unrealized field.

Oxy-Acetylene Welding and Cutting

By Hugh H. Dyar

Paper Presented Dec. 4, 1917.

Index No. 671

About four years ago I was asked to give a talk on the same topic that we are taking up tonight. When preparing the subject matter, I made inquiry to find out if any particular phase of welding or cutting would be of special interest and the party of whom I made this inquiry said, "tell them anything, they won't know the difference." I have thought a number of times since then that this gentleman spoke with greater truth than he realized as at that time the process was little known and just beginning to come into wide commercial use. I find that even today the majority of engineers and mechanics who are using the process every day in their business really know very little about the basic principles which permit us to get such good results and save so much time. They have quickly accepted the use of the equipment on account of the self-evident advantages and have gone very little into its theory or study.

Tonight I will go briefly into the history and development of the process and try to tell some of the things that are of most interest and of greatest value. The subject is of considerable importance to all in the engineering field, as I believe its development has only begun and the next five or ten years will see its use in practically every branch of mechanics. After telling you in a general way about the subject I will demonstrate several of its uses as much as the limited surroundings will permit.

The process originated in France and I believe the first torch used in this country was brought over by Eugene Bournonville in 1904; at that time a closely guarded secret. In 1907 Mr. Bournonville became acquainted with Mr. Davis, who was already in the acetylene lighting business and interested him in the welding process with the result that they sent to France and purchased the American patent rights on what appeared to be the best torch in use at that time. It is interesting to note that since then the torch has been widely developed in this country and it seems to be the concensus of opinion that our torches at the present time are superior to any obtainable abroad.

In the earlier development of the process other gases than acetylene were tried, the most important being hydrogen which, when burned with oxygen, gives a temperature of about 4,000 degrees Fahr. Acetylene gas being approximately 93 per cent pure carbon has very great possibilities for heat and when burned with pure oxygen a temperature of about 6,300 degrees Fahr. is obtained. This heat can be applied to metal quicker than it can get away by radiation. If two separate pieces are placed adjacent to each other and the flame applied the metal will flow and make one solid piece. This is called autogenous welding and differs from a blacksmith's weld, as it requires no hammering or pressure, also practically any metal can be welded by this process which is not the case with the blacksmith's weld.

As the name implies the two gases, acetylene and oxygen, are used. The acetylene is made from calcium carbide and water in a suitable generator that is automatic in operation and regulation. Oxygen can be obtained in a number of ways, by the electrolysis of water in which an electric current is passed through a water solution, by a chemical process in which manganese dioxide and chlorate of potash are heated, but for ordinary

*Representative, Davis - Bournonville Company, Cleveland.

commercial use is most easily procured in compressed cylinders.

The plant for welding and cutting consists of an acetylene generator, the oxygen supply being in tanks, the regulating and reducing valves and the torch or burner that actually does the work, and which is connected to the regulators by pliable rubber hose. For portable work the acetylene may be compressed in tanks filled with a substance a good deal like mineral wool which holds acetone in suspension. Acetone is a chemical which has the property of holding in solution 25 times its own volume of acetylene for every atmosphere that the gas is compressed. If the acetylene was not dissolved in acetone it would be explosive at high pressure.

In this country there are two basic methods of uniting the gases in the torch. The one first used and still adhered to by some manufacturers is known as the low pressure system in which the acetylene is supplied at a low pressure, three or four ounces, and drawn into the flame by the oxygen under high pressure a good deal on the principle of a steam boiler injector. The probable reason for this process is that when the art was new acetylene was only procurable from low pressure generators such as are used on farms and in isolated places for lighting. The power used to draw the acetylene into the flame has to come from the oxygen and as a general rule a large excess of this gas is necessary. However, this torch gives good results in some cases.

This method has been largely superseded by what is known as the high pressure system in which both gases are introduced into the flame under an appreciable pressure, a certain and constant mixture being produced. The theoretically perfect flame is one that uses equal parts acetylene and oxygen, and one of the leading torches has succeeded in burning these gases in the proportion of 1 to 1.14.

A very great number of different sizes and styles of torches have been developed according to the different uses that have been found for the process, varying from a jeweler's torch that is used to weld the precious metals to very heavy torches for handling the largest castings. In addition to the hand welding torch we have developed a number of machine welding torches which have been adopted very widely for tube welding where the seam is passed continuously under the torch, the weld being made at the rate of from 2 to 4 feet per minute. Such torches are water cooled as the service conditions are very severe.

A brief description of the acetylene generators might be appropriate at this time. These machines really consist of a tank or container with water in the bottom and a carbide hopper in the top. A mechanical device run by a weight discharges the carbide into the water, acetylene being produced which is maintained at a constant pressure by a diaphragm control which stops and starts the feeding mechanism.

Welding

In welding cast iron the piece is first prepared by chipping out the crack in the form of a V so that the weld can be made the entire thickness of the metal, thus producing a weld of full strength. In handling cast iron where the shape is somewhat irregular as is usually the case the proper heat treatment is fully as important as the actual making of the weld. For ordinary work the casting should be heated very slowly, usually in a charcoal fire until it has become a dull red and any expansion strains taken care of; the weld should then be made while it is still at this temperature and afterwards cooled down very slowly. Those of you who are foundrymen or have had experience in handling cast iron know that if this plan is not followed strains are very apt to be developed that will

crack the casting when it becomes cool. One of the difficulties often spoken of in welding cast iron in which the welded spot is very hard, in fact too hard to be machined, can be prevented by the proper heat treatment; there are, however, a number of other things that have a bearing on this. By the use of a high pressure torch some very remarkable and large welds have been made. Drop hammer frames, flywheels up to 20 feet in diameter, and any number of large engine beds and machine frames have been successfully welded by this process. The softer metals such as brass and aluminum which are usually in the form of castings have to be heat-treated much the same as cast iron, but on account of their lower melting temperature they are, of course, not heated to such an extent.

In welding steel expansion and contraction are not of such great importance as in cast iron. On account of its ductility and greater strength the heating strains, while they are present to a certain extent, do not cause the trouble encountered with castings that are more brittle. In important work such as repairing boilers strains are taken care of by a special preparation of the sheet.

One important branch of welding is met in the manufacture of steel containers such as barrels, tanks, battery cans, metal furniture, etc. In this work one of the principal difficulties is the arrangement of proper jigs and fixtures to hold the metal while the weld is being made. Steel is apt to buckle or become wavy when heat is applied along the edge and unless the proper arrangements are made to hold it a poor job will result.

Automatic machines have been developed for welding barrels and tanks in which the torch is carried along the seam by a carriage similar to that on a lathe. This will do the work in less than half the time it can be done by hand and produces a very thin and fine piece of work.

In all welded work the question of strength of the joint naturally comes up. Joints properly made with the high pressure torch producing a neutral flame should give very nearly the full strength of the metal, and in actual work wherever possible the weld is made thicker than the balance of the metal leaving a greater cross section in this spot which produces a 100 per cent weld.

Cutting

Of equal importance to welding is the cutting of steel by the oxy-acetylene process. It seems almost impossible that steel up to a thickness of about 20 inches can be cut by a tiny flame about as rapidly as wood can be sawed. The torch used for this work is similar to the welding torch except that in addition to the regular oxy-acetylene flame a jet of pure oxygen can be turned on which actually does the cutting. The piece to be cut is heated on the edge with the regular flame, after which the oxygen is turned on. A hand torch is used for miscellaneous work such as cutting out patches in boilers, cutting irregular shapes in plate which were formerly punched out, cutting steel "I" beams and in wrecking steel buildings. In a number of cases this work has been done at from one-fourth to one-sixth the cost of any other method. One important use is the cutting of risers on steel castings.

A machine built on the principle of the common drawing-board pantograph has found a wide commercial application in cutting out dies and stripping plates, cams of irregular shapes, the butt end of connecting rods, etc. It is really a remarkable machine and was classed by the Scientific American magazine as one of the greatest inventions of this generation. The motor will run on either direct or alternating current of 110 or 220 volts and the pointer has a constant speed of travel through a train of gears. The pointer is guided over a drawn design and the same design is cut out of the metal.

TORCHES

I think it will not be out of the way to say a word or two regarding the many different makes of torches on the market. The process has developed so rapidly in this country that naturally a great many concerns have been attracted to it and have attempted to manufacture and sell apparatus. Many of these concerns have had a very superficial knowledge of the subject and are irresponsible, their chief selling argument being the low price of their equipment. Some people attracted by the low price have purchased such equipment with the natural result that they were unable to do much with the process, and condemned it, and if any of you are contemplating the purchase of apparatus you will save money in the long run if the best is purchased.

DISCUSSION

R. E. STARK.—A point has come up quite recently of a keyway cut in a cylinder. You might call it a keyway due to the fact that the wrist-pin became loose. The makers of the machine suggested putting a little cast iron in with the acetylene torch and boring or turning it out, and then lapping in a new piston. I would like to have a little information as to whether it is a proper procedure, and if it will produce an engine as good as new.

HUGH H. DYAR.—An engine as good as new is a pretty good engine. There are concerns in this country, a great many of them, who do nothing else but weld scored cylinders of different kinds and then rebore them. I would say that on the bulk of automobile cylinders this procedure can be followed without any trouble at all. We weld a great many large cylinders in which a similar thing has happened.

There is a method I might mention, in addition to welding, which consists of applying what is sometimes called silver solder; I have heard it called nickel silver, although the bulk of it is block tin, that is very good. The only precaution necessary is to be sure the score is clean, that there is no grease left in it, and you can apply this metal without preheating your cylinder. If you want to weld up that score it will probably be necessary to preheat the entire cylinder, which, if it was not properly done, may lead to distortions of one kind or another. It depends a good deal on the way it is heated.

W. L. ELY.—You spoke of the use of the flux under certain conditions. Do you have a different flux for the different kinds of welds, or is there one uniform flux that you use; for instance, for cast iron and welding steel? Would you care to state what, in your experience, has proved to be the best flux?

HUGH H. DYAR.—I have found that in the bulk of steel welding a flux is not necessary. The purpose of any flux, of course, is to float the oxid that may accumulate, or to float other dirt that may be in your weld. We find that in the steel the oxid or dirt comes to the surface and it is very seldom that it is necessary to use flux. With cast iron the situation is different. We use a flux for that. We also use flux for brass and bronze, the basis of which is plain borax. Some people add this and some people add that to it, but my experience is to take a little borax, and if it is handled right you can get by in pretty good shape. There has been an extensive study of aluminum flux. Oxid of aluminum melts at a very much higher temperature than aluminum itself, so if you try to puddle your weld and get the oxid to float, you will melt through your casting and you cannot handle it. In welding cast aluminum we find that it is often good practice in making your weld to take a steel stick and keep breaking it up, keep puddling your weld with a steel stick which mechanically breaks up the oxid. I should say a weld made in that way

properly executed would give a strength of 80 per cent.

In these aluminum welds we run onto a very difficult problem, because a very light tip with a torch will go through the pieces unless you watch it closely. Up until about a year ago practically all of the aluminum flux of the better grades used in this country came from the other side, from Germany and France, and lately from Switzerland; but we are developing fluxes now that are very satisfactory.

Member.—It might be of interest to know that the use of the oxy-acetylene welding process in the Michigan Central Railway shops during the month of September, this year, was responsible for the saving of $75,000.00.

H. V. Schiefer.—You spoke of a torch for welding material from ¼-inch thick up. In the average structural shop, they are up against the proposition of the ordinary structural steel which runs from a quarter inch to three-quarters of an inch. Now that same man is confronted with the proposition of making gear guards which he does not want to make any heavier than absolutely necessary, from 1/16-inch up to probably 3/16-inch. In your experience, have you run into the problem of making gear guards, and is it necessary or economical to get a special torch for the manufacture of them? Also have you run on any happy medium of a proper thickness which would give the most economical results? For instance, is No. 10 cheaper to make than No. 14 because it is easier to handle? Any general information as to the manufacture of light gear guards for machinery purposes would be appreciated.

Hugh H. Dyar.—About four or five years ago, the Morgan Engineering Company, at Alliance, Ohio, went into the welding of gear guards quite extensively. The small guards, the ordinary run of which, we will say, will take up to about a 4 or 5-foot gear, are made of about 14-gauge steel. The method of procedure in gear guards of that type is about this: The gear guard will probably be made in halves. We cut out the irregular shaped piece and cut out and bend the piece that goes over the top. It is then customary to make a number of tack welds. After it is tacked on both sides it is a simple proposition to start right through and make your weld all the way around. In practice it is customary to use a flat surface with a number of clamps to hold the pieces in position while welding. That would not be worth while going into if you only have a few guards to make, but if you have a lot of them to make it would probably be a good way of going at it. One of such jigs I have seen has a pin with a number of rotary arms, that being made out of steel angle about 1 inch on each leg, possibly ⅛-inch thick. There is a slot in one end, an arrangement so it can be clamped down, and the piece is simply clamped down and the entire weld made. If it is handled that way, you will require only one or two tacks, just enough to give it its shape. As far as the gauge of metal goes, I think you can use about as light metal as will hold its shape. One great advantage is that the weld is oil tight. Even if you make it out of only 16 or 18 gauge, it will be oil tight. Of course, if you try to make it by the riveting method and want it oil tight, you will have a job calking up an edge that thick.

W. J. Oettinger.—Do I understand it is welded onto the angle?

Hugh H. Dyar.—No, it is welded onto another sheet. It really forms a box, and there is a weld at the corner.

W. J. Oettinger.—Why could not that be used in tanks?

Hugh H. Dyar.—We have a number of special jigs, and also a special machine for welding tanks. It is quite important to clamp the edges of sheet metal tanks while they are being welded. We have gone quite extensively into the clamp proposition,

and now make some of them out of cast iron, with a water-cooled chamber in which the water is circulated continuously so that the clamps will not become too hot and get out of shape.

MEMBER.—What is the rate of welding in feet, and does it vary with the thickness of metal to a great extent?

HUGH H. DYAR.—Yes. The speed of steel welding varies almost directly as the thickness of the metal varies. On No. 14 gauge a good welder will run along at the rate of about 6 inches a minute. When you get up to ¾-inch plate a man probably would not weld more than 1 or 2 feet an hour.

One thing comes to my mind that some of you might be interested in, and that is the relative tensile strength of the weld compared to the original metal. We find in practice that where the weld is of the same thickness as the plate you can count on around 75 or 80 per cent for an average job. I pulled a number of test pieces in the puddling machine that are broken outside of the weld, showing over 100 per cent, and I have seen some pulled that showed less than 50 per cent. That is a thing that is hard to determine unless you know the welder. There is now being developed a machine on the X-ray principle which will enable you to look into the weld and see what is there. If there is a cold shut or dirt in there it will show up, and I believe that machine will go a long way toward solving the riddle of what is in the weld.

It is practicable wherever possible to make the weld of greater cross section than the sheet, in which case you can always count on over 100 per cent joint. The increase in cross-section would be about 25 per cent, and I believe if you pull a weld of that kind properly made it will not break in the weld.

W. L. ELY.—In welding cast iron we sometimes experience difficulty in machining the welded portion due to hardness of the weld. Is this due to the excess of carbon in the welding stick, or is it due to the method employed by the operator?

HUGH H. DYAR.—My theory of that is that if the welder is not quick with his work, or if he uses a torch that produces an excess of oxygen in the flame, he is liable to burn out of the cast iron the free carbon. As we all know, it is the free or graphitic carbon in the cast iron that makes it soft. If you burn that out, you approach to a greater or less degree the white iron, which has practically no free carbon in it. I have heard a number of other theories, but I believe the one I just gave is probably the most accurate. If you watch the weld and see that the torch does not give an excess of oxygen you will not have a great deal of trouble. Sometimes if a cast iron weld is allowed to cool too rapidly it will be chilled, and I have seen some welds made in that manner that were harder than the devil's back, you could not touch them with anything. You know what white iron is, and that is what you get.

The filler rod that is used for welding cast iron contains a high percentage of silicon. That silicon, of course, is to absorb or do away with the phosphorus and sulphur and other elements of the iron that would be destructive, and the filler rod also contains quite a high percentage of carbon. If you can get free carbon in the weld it will be soft, and if you do not it is pretty likely to be hard.

ED. LINDERS.—Some time ago I happened to inspect a cast iron gear that had a bad defect in it, and they offered to weld it. I told them if they could make a good job, all right. Is there any way of knowing what they are getting hold of? These inexperienced men who use this stuff pick up what they can find and use it.

HUGH H. DYAR.—If I find a man using a torch that cannot tell the dif-

ference between cast iron and steel in the form of a rod, I would not want him to be a welder. It has been the practice of some concerns to sell a welding outfit like sugar over the counter. You buy your outfit. If they get your money they say good-bye, with the result that you try to use it and not knowing anything about it, find out you cannot use it. Some of them putter along and may get hold of some fellow who has a gear that needs to be welded, and take a chance on it. The probabilities are if you take that fellow's weld and hit it with a hammer it will come off. I think that has done more to retard the development of oxy-acetylene welding than anything else—inexperienced men trying to do the work. But we find now that those fellows who bought the cheap outfit are buying the better one, so that the fellow who sold the cheap outfit is really doing missionary work.

J. C. Lincoln.—Suppose you want to weld half-inch boiler plate. How do you prepare the edges of the material to make the weld?

Hugh H. Dyar.—We find that up to about 3/16-inch, in some cases more, you can burn right through the metal and make a satisfactory weld without any previous preparation of the metal, but work heavier than that, and in cast iron repairing, we would chamfer it out, start making our weld at the bottom and gradually build it up. As we built it up, we would melt over the edges.

J. C. Lincoln.—About what angle would you prefer on those chamfered edges?

Hugh H. Dyar.—I would say that 45 degrees between the angle would be all right.

J. C. Lincoln.—That would be 90 degrees between the two pieces.

Hugh H. Dyar.—No, 45 degrees. Some welders will chamfer their material out a great deal wider. In my opinion it is best to make the edges as narrow an angle as you can, because the more metal you have to weld in the more gas you use, and the more it costs.

J. C. Lincoln.—Have the various temperatures been explored so that it is pretty well known what the approximate temperatures of the flame are?

Hugh H. Dyar.—I do not like to be quoted, or say much about those things, for the reason that my statements may be disproved later. I am a little bit inclined to be conservative in going into that proposition.

We find that the most effective point in the flame for welding is just beyond the light cone. Any of you who have seen the oxy-acetylene flame know it resembles a small bunsen burner flame.

J. C. Lincoln.—Just beyond the tip of the white flame?

Hugh H. Dyar.—Yes.

J. C. Lincoln.—Is the oxygen on the inside or the acetylene on the inside?

Hugh H. Dyar.—Well, we try to mix them together.

J. C. Lincoln.—There are two concentric tubes. Does the inside tube carry the oxygen or does it carry the acetylene?

Hugh H. Dyar.—Those tubes really have nothing to do with the mixture of the gas, because it takes place in the tip. One gas is not concentric to the other.

J. C. Lincoln.—The reason you do not get flame inside the burner is because there is velocity enough in the tube so that the flame cannot get to the point where the gases first mix. Is that the reason it does not burn immediately?

Hugh H. Dyar.—That is exactly the idea.

J. C. Lincoln.—What is the diameter of the hole through which the mixed gases pass?

Hugh H. Dyar.—It depends upon the size of the tip. You see the torches take a number of different sized tips depending on the thickness of the work to be done.

J. C. Lincoln.—I imagine it would be very easy to get to the point where the opening would be large enough so that the gases would explode. There is certainly an explosive mixture in there, and the only reason it does not explode is on account of the velocity of the gas. Of course, if you get the aperture large enough it is going to explode back in the tube.

Hugh H. Dyar.—Yes.

J. C. Lincoln.—What is the limit to the size of the hole through which the gases can pass?

Hugh H. Dyar.—You mean on the small size or on the large size?

J. C. Lincoln.—You have a tube there through which mixed gases pass?

Hugh H. Dyar.—Yes.

J. C. Lincoln.—It would be 3/16 or 3/32 in diameter?

Hugh H. Dyar.—Yes. Those holes run in diameter from a No. 70 drill, which is just a few thousandths, to nearly ⅛-inch in diameter.

J. C. Lincoln.—That is the hole through which the mixed gases pass?

Hugh H. Dyar.—Yes. These holes, of course, are very small. The idea is to have them small so there will be a great reduction in the pressure, which will give you a good mixture.

J. C. Lincoln.—You say the upper limit of that is 3/32. Did you say that is the practical limit for the diameter of the hole in the tube?

Hugh H. Dyar.—That is as far as we have gone in practice. I do not know what the upper limit is. If you go beyond that, you have so much heat you cannot control it. On some of the old torches, the velocity of the oxygen going through was so great that it would make a flame with a hollow core of oxygen, so when you got it on the steel it would have merely a cutting effect. I have seen some fellows get hold of that, and they would say, "By gosh, we are certainly getting speed out of that torch." They were not welding at all, they were simply burning their metal. There is a difference between burning and welding. The process during the last two or three years has developed so that we know a good deal of the construction of welds through micro-photographs and other means, and it is easy to tell a burned weld.

J. C. Lincoln.—Is it a very particular job to mix those gases so that you do not get an oxidizing weld? You do not have to mix those gases very accurately in order to get the proper reducing and oxidizing quality, do you?

Hugh H. Dyar.—I would say you have to design your torch very carefully or you will get an excess of oxygen. You see an excess of oxygen does not necessarily form in the flame, but if it is there it will burn. In the high pressure torch we try to use as much atmospheric oxygen as we can. Practically all the oxygen we use is consumed right at the cone of the torch, and the balance of the flame outside is using atmospheric oxygen.

J. C. Lincoln.—That means the flame itself is reducing quite strongly.

Hugh H. Dyar.—Well, it is supposed to be neutral. If you get a reducing flame you are liable to run into other difficulties. You get a high percentage of carbon.

J. C. Lincoln.—Is the mixture controllable by the operator or by the design of the torch?

Hugh H. Dyar.—Both. If the torch is properly designed you can draw down the flame to the point where you get the bunsen cone, and you have a neutral flame. But it is very easy to get an excess of oxygen if the torch is not properly designed. Once in a while we get a torch that has a reducing effect, carbonizing, but not very often. I have seen some torches that would use twice as much oxygen as was necessary.

J. C. Lincoln.—With such a flame you cannot possibly make a good steel weld, can you?

Hugh H. Dyar.—No, sir. When you get too much oxygen in the welding flame you approach the cutting condition. The product of course is a common oxid of iron, I think it is Fe_3O_4, and I have seen some welds that were pretty nearly Fe_8O_4.

J. C. Lincoln.—They would not pull 100 per cent?

Hugh H. Dyar.—No, they would not pull 100 per cent.

Member.—Isn't the oxy-hydrogen flame suitable for making cuts? You get the long flame and the oxidizing effect?

Hugh H. Dyar.—It has been our experience, and we have gone quite extensively into the matter, that for cutting up to I would say 8 or 10 inches thick the oxy-acetylene is best and cheaper. For cutting over 10 inches thick, and from there on up to the limit, the oxy-hydrogen flame is better. I believe one reason is that the oxy-hydric flame is not a short flame; it is more likely to be a long tongue that comes down into the cut and keeps the oxid flowing out. If you do not get the heat deep enough you are liable to get a frozen cut.

Member.—A question came up today about repairing a worn pinion in a heavy wheel, about 17 teeth, 4-inch pitch, cast and threaded. The pinion has worn apparently about 3/8-inch on all the teeth on one side. The party wants to know if that pinion can be welded and a new face put on the tooth without taking the pinion off the shaft.

Hugh H. Dyar.—No, it would not be practicable. To begin with, when you put the heat on a pinion, the first thing it would do would be to expand. By the time you got the sides of those teeth welded you would have spent more money in gas and time than a new pinion would cost. There are limits to the oxy-acetylene process just the same as there are limits to everything else under the sun. It is not a cure-all. Very often we run into difficulties that cannot be overcome. I have had some rather unusual experiences. I received a letter the other day from a man in Youngstown who worked in one of the steel mills, whose uncle had a coal mine down in Ohio, and he wanted to know if the same torch used for cutting steel could be used for coal mining. I referred him to the Ingersoll-Rand Company.

Member.—I should like to ask if you have had any experience with the lead welding with your outfit?

Hugh H. Dyar.—We can weld lead very successfully with the small torch. You can weld lead successfully with the oxy-hydric torch; in fact, with most of the high temperature torches, because, as we all know, it does not take a great deal of heat to melt lead.

Member.—Do you use the same design of torch?

Hugh H. Dyar.—No, we use a very small torch.

I. E. Waechter.—One gentleman has complained about the hardness of cast iron welds. You explained that it was due to the burning out of the graphitic carbon, leaving only the combined carbon, which, due to the chilling effect, makes the weld very hard. Another gentleman spoke of reducing flame due to insufficient oxygen. It seems to me that if you would use a reducing flame in welding cast iron, no carbon would be burned out, as a result of which the weld would remain soft.

Hugh H. Dyar.—That is just exactly the situation. If you use a neutral flame, or a flame that contains a little excess of acetylene, the probabilities are you would get a soft weld.

We have recently found a fairly satisfactory method of welding die castings. Up until about a year ago if we got a die casting in the shop, we would let it stay there until some one came and got it. We could not do much with it. But I find now that most all of the die casting alloys can be handled to a more or less sat-

isfactory degree by the use of tin. We have done some very satisfactory jobs on automobile parts and lubricator parts and pump parts and magneto parts, die castings, by simply using block tin.

J. C. LINCOLN.—About what pressure do you use in your bottles containing the gas?

HUGH H. DYAR.—The pressure in those oxygen cylinders when they are full is 1,800 pounds, and it is reduced in the reducing valve to what we use on the torch. The pressure we use on the torch varies according to the work we are doing. We have some very small jobs we only use a few pounds pressure, and on cutting heavy armor plate 18 or 20 inches thick, it will run about 125 to 150 pounds oxygen pressure.

J. C. LINCOLN.—Is your acetylene about the same?

HUGH H. DYAR.—No, the acetylene never exceeds 10 pounds. It runs from a few pounds on the very small jobs up to about 10 pounds. The average pressure is about 7 pounds.

J. C. LINCOLN.—What is the reason for the difference in the pressure of the two gases?

HUGH H. DYAR.—We have found that at those pressures if the holes are drilled properly we get a proper flame at the velocity we want. I have seen a good many torches with the flame so fierce if you tried to use a light welding stick it would blow it away, and you could not get results. I have seen some torches where the velocity was so low it would not get down into your metal at all, it would simply burn. There is quite a lot to a torch. They look simple, but they are the result of a good deal of experimenting and research.

R. M. MORGAN.—What is the average area of the two acetylene holes to the area of the oxygen holes? Are the combined areas of the two acetylene holes equal to one of the oxygen?

HUGH H. DYAR.—The area of the acetylene holes is greater than the area of the oxygen hole, for the reason that the acetylene is applied at a slightly lower pressure than the oxygen. We aim to get equal volumes of the two gases in the torch, and we have no difficulty in getting one to 1.14 under almost all conditions. I have seen those figures vary slightly in the laboratory, but if you try to cut the flame down too low it loses its effectiveness.

JOHN MCGEORGE.—Could you give an approximate idea of what would be the cost of welding say a foot of No. 16 plate together?

HUGH H. DYAR.—The cost of welding a foot of No. 16 gage material would be, I would guess, about one cent.

JOHN MCGEORGE.—One cent for gas?

HUGH H. DYAR.—For gas only. There is a good deal of difference in the welders. I have seen some welders that would get the same results and use half as much gas as others. I might say that a number of the large companies that are interested in the oxy-acetylene process have opened schools for welders. We have such a school going in our factory at Jersey City now. At the present time a great many of the welders from the Quartermaster's department are going through it. They come in lots of 25, and take a two weeks course. They will probably be non-commissioned officers in the Quartermaster's department. I have heard some men selling this stuff who would say you can learn how to weld in a couple of days. That is not true. It is just the same as any other trade. You would not take a man out of the ditch and put him on a screw machine and believe that he would turn out a good article with a few days' instruction. It would take him longer to learn how. You would not take a farmer and put him in a foundry and expect to make him a molder in a few days. It cannot be done. It is the same way with welding. You cannot pick it up over night. That is

why we have these schools.

A. F. Blaser.—Is it good practice along street railway tracks to fill in worn out parts, as for instance, frogs that are somewhat pounded down? Can they be filled in by this process, and if so, what precautions are necessary?

Hugh H. Dyar.—Why, it is entirely practicable, and it is done to a limited extent. The reason it is not done more is the expense. In that field we have a competitor in the electric arc welder. In street car work, the electric welder can simply reach up and grab a few kilowatts and make his weld at practically no cost other than the labor. I might say that it has been my experience that those electric welds are very seldom as strong as acetylene welds. That is not only my experience; it is the experience of a good many of the boiler inspectors who have tested out both types, and I believe I am safe in quoting that statement. You do not get the tensile strength with the electric arc weld that you do with the acetylene. I have seen a great many frogs and rail joints welded with the arc, and after they had been run over for six weeks or so, you would find little scales of steel come off about the size of your finger nail. You would find a pile of them around that weld. My theory is this: I believe that every particle that you drop on with the electric arc is covered with a thin film of oxid and when it comes down that film may be broken out more or less, but that is in the weld, and if it is subjected to punishment, as it is in the case of street car work, they do come off. You can take your acetylene torch, and if necessary puddle in a little area, and your oxid will come to the top, as well as your dirt, and you will get a strong weld. I did a job of that kind in New York state a number of years ago—I had a lot of time, used to have in those days, for it was hard to sell this stuff—and after we got our welding done and had our piece red hot, we built a little dam around there with some dirt and mud and tempered it. The last I heard, those jobs were a good deal harder and standing up better than the rail itself. But of course that is too expensive to be common practice. I think the electric arc is the most extensively used process for building up what they call cupped joints on rails, or building up frogs or work of that sort.

J. C. Lincoln.—Is it possible to get material in a weld of say half-inch boiler plate in which the welded material is capable of elongation?

Hugh H. Dyar.—Here is the situation in that respect: When you are welding a steel plate, always remember this: Your weld, wherever it is, is cast steel, and the balance is open-hearth or rolled steel, which of course signifies that the grain in your weld is coarser than the grain in the balance of your plate, and for that reason we do not get the elongation nor the ductility in the weld that we do in the sheet. Now, I have seen some fellows preparing test coupons, who anneal their weld, which can be done in practice very frequently, or they can hammer it. By hammering it they try to close the grain, make the grain finer, and thereby get a stronger job, and you do get slightly better results that way; but I find that the hammering only takes effect on the surface. On a half-inch test coupon, if you hammered the weld, I do not believe you would find the grain would be fine for a depth of about 10 or 15 one-thousandths. It does not sink into the metal. Where the welding is, you have practically cast steel, whereas the balance is rolled steel. That is why you do not get the elongation and conductivity. For the wire, we used to get a very fine grade of pure Norway iron that was exceptionally clean. That made a very ductile weld. We cannot get that now.

A. Tashjien.—How about drilling armor plates or anything like

that? Can you burn through a clean cut hole in armor plate or steel plate or any other kind of plates?

HUGH H. DYAR.—A clean cut is rather a relative term. What I might call a clean cut you might not. But with the use of the machine we can get a cut that approximates a saw, with the exception that it has oxid on it. With the hand torch we cannot get so smooth a cut, due to the motion of the operator's hand. We make a good many holes with a torch for rivets for riveting work, and they work out satisfactorily, but it is not as smooth as a drilled hole. Our torch will pierce steel up to about 2 inches thick. When you get above that you cannot pierce through.

ED. LINDERS.—Do you have any trouble with different grades of steel, for instance steel used for billets where you have a layer of hard and soft?

HUGH H. DYAR.—We have found that some of the alloys, the tungsten, manganese, some chromium alloys are hard to cut. You can cut them by heating them, heating the entire piece, which very often in practice is not practical. But we can cut steel of practically any carbon, from the low, open-hearth steel, even wrought iron, up to 125 tool steel. I might say that in cutting heating the piece facilitates the work very much. You use less oxygen, and you can go quicker.

MEMBER.—Can they regulate the depth?

HUGH H. DYAR.—Not yet, no. You have to go all the way through, that is to get rid of your oxid. I think we will have something to say along those lines in a little while.

Electric Arc Welding

By Robert E. Kinkead*

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In presenting a paper to a body of engineers on the subject of electric welding, it seems advisable to treat the subject in general terms and to cover, so far as possible, the whole field, allowing points of particular interest to come up in the discussion to follow.

There are two general kinds of welding, namely, that which requires heat and mechanical pressure and that which requires heat only. The first kind of welding includes forge welding, electric butt and spot welding, and electro-percussive welding. The second kind of welding includes the thermit welding process, the oxy-acetylene and electric arc processes. The latter two processes are called autogenous welding processes. An autogenous weld is made by heating the metals to a liquid state and pouring them together into a homogeneous molten mass and allowing them to cool. The source of the heat required to melt the metal does not alter the principle of the operation, but does necessitate different methods of performing it. With very few exceptions the same operations may be accomplished with either the oxy-acetylene or electric arc process. The electric arc has a higher temperature than the oxy-acetylene flame and the great part of its heat is produced in an extremely localized area *within* the metal to be welded rather than external to it, as is the case in the oxy-acetylene flame. The heat of the arc being produced in the metal is more efficiently used so that it is possible to do at least three times as much welding with a given amount of heat produced by the electric arc as would be possible with the same amount of heat produced by the gas process. The approximate heat quantities involved in the welding arc are easily calculated from this formula:

$$H \text{ equals } \frac{E \times I}{1{,}000} \times T \times 3{,}413.$$

H equals heat in British thermal units.

E equals average voltage across arc.

I equals average current in the arc circuit.

T equals time arc is in operation in hours.

The factor 3,413 is the heat equivalent of one kilowatt-hour energy in British thermal units.

The heat liberated by the oxy-acetylene flame may be calculated knowing that a 1 cubic foot of an oxy-acetylene burned oxygen gives about 1,550 British thermal units of heat.

The cost of producing a unit of heat for autogenous welding with the present prices of gas and electric power is about in a ratio of gas, 3; electric, 1. With an "effectiveness" factor of about one to three in the use of the two processes, it is evident that the cost of gas is in the neighborhood of nine times the cost of electric power doing the same work.

Up to the present time the electric arc welding process has been used almost exclusively in the welding of steel. The very great localization of heat of the arc gives it a marked advantage over the oxy-acetylene plant for welding on boiler plate and sheet metal. The difficulties arising from expansion and contraction with the attendant buckling of the plate and cracking of the weld encountered in the use of the gas process are, to a certain extent, eliminated in the arc process due to this localization of the heat.

Gray iron may be welded with the carbon arc welding process, but

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the operation is somewhat more difficult than welding with the gas flame and perhaps requires more skill on the part of the operator.

The commercial applications of the electric arc welding process are very interesting. By the use of the process it has been possible to accomplish certain things which were not possible before. It is often possible, by its use, to accomplish in a few hours essentially the same results which a few years ago would have required ten times the labor and perhaps ten times the actual working time. The use of electric power for autogenous welding is another triumph for electricity.

One of the most interesting applications of the electric arc welding process is in the locomotive shops and round houses of the country. This is an application which is growing in importance daily. The steam locomotive is merely a large number of pieces of steel bolted or riveted together. Each piece and the whole is subjected to the most severe strains. Most of the parts are subjected to excessive wear, and the boiler is worked to the limit of its capacity under most unfavorable conditions. Under present war-time conditions of railroad traffic, motive power is being kept on the road double the number of miles that was considered possible two years ago, before finally coming back to the locomotive shop. The electric arc welding process is used to weld the flues into the back-flue-sheet of the boiler; to weld cracks and patches in the fire-box; to weld in new sections of the flue-sheet, door-sheet or side-sheets. Broken frames are welded in from six to ten hours without dismantling the engine. Worn links, guides, hangers, etc., are built up with new metal, remachined and put into service in a few hours time. Worn flanges on the drive wheels are built up without dropping the wheels and the engine is put in service without turning the tire.

I submit copy of a paper presented by E. Wanamaker, Electrical Engineer of the Rock Island lines, in which he presents some very interesting facts in this connection. One of the most interesting is that by the use of the welding process they have obtained from their present motive power equipment the same service that they would have obtained with 23 additional engines but without the welding equipment. Mr. Wanamaker's paper on "War and Welding" is one which every railroad man in this country ought to read. If there is anyone who has any doubt as to what the engineers of this country must do as their share to help win the war, a study of the results which Mr. Wanamaker has obtained is to be recommended.

COPY OF PAPER

WAR AND WELDING

By MR. E. WANAMAKER, Electrical Engineer, Rock Island Lines.

In addressing the Western Railway Club on the subject of operating economy, I feel that it is entirely unnecessary to enumerate the reasons why it is necessary for the railway systems of the country to exert the maximum effort to move the freight of the country with the greatest possible dispatch. That is a lesson which we have learned as the result of the campaigns which have already been fought in Europe. We have the example of the remarkable effectiveness in transportation which has been reached by Germany, and, on the other hand, have witnessed the most complete failure of the Russian military effort, due to lack of proper transportation facilities. The paper presented to this club on September 18th by Mr. W. L. Park, Vice President of the Illinois Central Railway Company, together with the discussion following it, deals with this subject in a very excellent manner.

So far as we can see at present, the railroads of the country will not be burdened as seriously, due to the necessity of transporting the armed forces of the nation, as they will be burdened with the transportation of food for the seaports, and the multitude of commodities which require transportation to be manufactured into munitions of war, and which later must be delivered to a seaport for ocean transportation to the theater of war. This latter transportation service is in no way different in quality from the ordinary industrial transporta-

tion service which the carriers must render in time of peace. However, there is an enormous difference in the quantity of service required. The effectiveness of the nation in the war is a function of the time required to put effective fighting units in the field and keep them properly supplied with food and the implements of war. The ability of the railroads to meet the demands upon their transportation facilities will be an important factor in the time required for the nation to become effective on the battle fronts.

This discussion deals with one way of getting more transportation service out of the railway equipment in existence at the present time. Efforts spent in this direction are as patriotic and necessary as can be imagined. I do not wish to depreciate for a moment the patriotism of the man who puts on the uniform and risks his life "to make the world safe for democracy". I do insist, however, that the patriotism of the civilians, particularly of the mechanical engineers in railway service, must not stop with the more or less superficial demonstrations of loyalty to the stars and stripes. Those of us who cannot go to the fighting front must use the best of our abilities to get service, "and still more service," to paraphrase Lloyd George's quotation, from the motive power and rolling stock of the nation's railway systems.

The growing possibilities of the welding processes in motive power and rolling stock maintenance have been a source of amazement to every railway man who has come in contact with the practice. From an engineering standpoint, the welding processes are particularly interesting. In the matter of cutting metal the improvement in practice brought about by the introduction of the oxygen torch is particularly great. Only a few years ago the shearing of plates was the only method used for cutting plates, etc., to the proper size for manufacture and repair purposes. It was slow, inaccurate and wasteful. The cutting of large holes and special shapes after the plate had become a part of a boiler or machine had to be accomplished with drill and chipping hammer. The cutting of rivet heads, bolts and nuts was an operation which took an unreasonable length of time and required an expenditure of labor all out of proportion with the results accomplished. In such operations the application of the oxygen cutting processes saved from 50 to 90 per cent of the time required to perform the operation. Yet I regret to state that in many of our locomotive shops and car yards the old practices are still followed and our man power for this cause has not produced the maximum result.

The matter of fastening two pieces of metal together is one of the fundamental problems of mechanical engineering, since all machines are made up merely of so many pieces of metal fastened together. The rivet is almost as old as the hammer and anvil. The threaded bolt and nut, as compared with the rivet, are recent inventions. The welded fastening came down to us from antiquity. The welded fastening has always been looked upon as a stronger joint than the riveted or bolted fastening. The reason that it was never more widely used until recent years has been due to the fact that only one way of making a welded joint was known, and that this was not applicable, except to a limited range of joints. As a general proposition the riveted joint, or bolted joint, has a tensile strength which is considerably less than the tensile strength of the original piece, while the welded joint is as strong as the original section. For instance, two pieces of boiler plate may be riveted together with four rows of rivets and double straps, and the tensile strength of the joint will not exceed 85 per cent of the strength of the original plate, yet it is quite a simple matter to weld a joint in the same plate, either by the old forge welding processes or by later autogenous welding processes, and obtain a joint that is as high in tensile strength as the original plate. The reason more of such welded joints have not been produced prior to the introduction of the autogenous welding processes has been due entirely to the difficulty experienced in applying a forge weld to the structures made of plate. The welded joint, and particularly the butt welded joint made by an autogenous welding process offers greater strength, with a thickness for practical purposes equal to the thickness of the original plate. This is a feat in mechanical engineering which has been unheralded, but ranks with the introduction of the power hammer, the pneumatic tool, and other great strides in mechanical engineering progress.

There was a time when worn surfaces of the steel parts in a machine made it necessary to scrap those parts. There was no method, aside from the using of chafing plates, of avoiding this practice. The wearing of a fraction of a cubic inch of metal from one of the wearing surfaces of a steel part made it necessary to scrap the labor investment in that particular part entirely. It was only with the introduction of the autogenous welding processes that it be-

came possible to stop this economic waste. This also ranks as an important engineering achievement, and it has only been in the last three years that the possibilities in this direction have begun to be realized. While it has not been possible to apply this salvage to cast iron parts to any great extent, the tendency has been towards the introduction of steel castings in place of gray iron castings to accomplish the desired result.

The repair of broken members of a machine has been another important work of the autogenous welding process. Prior to their introduction certain steel parts could be welded in the forge fire, but the range of the work was very limited and in many cases its cost equal to the cost of a new part. Now, however, with the exception of cast iron parts, the failure of which would bring death and destruction, practically all parts of a machine which break may be safely repaired.

Viewed from the perspective of the last 50 years, the achievements made possible by the autogenous welding processes in the last five years are probably the most remarkable of any in the mechanical field. It is my purpose to point out so far as is possible how far these new practices may be utilized on steam railways to enable the railway systems of the country to meet the present emergency in the matter of service demanded from motive power and rolling stock equipment. It seems advisable to preface my remarks on the newer processes with a short discussion of their relationship to the older and more established practices.

Forge welding has probably been practiced ever since man had intelligence enough to construct a crude anvil and a hammer. It rests on the fact that when two pieces of iron are raised to such temperature that they become plastic, they may be forged together and will become, at the junction, a homogeneous mass. The art of forging depends upon three things:

1. The surfaces which are to be welded together must be clean so that the molecules of iron may come into intimate contact during the operation.
2. The temperature of the metals must be such that cohesion of the molecules may take place, but must not be high enough to depreciate the physical properties of the metals.
3. The mechanical pressure must be applied in such a manner as to bring the molecules into such intimate contact that cohesion will take place.

The first of the new welding processes, which may properly be called autogenous processes, since the welding takes place more or less automatically, was the thermit welding process. In this process the metals to be welded, together with the additional quantity of metal of approximately the same composition, are heated to a liquid state by a chemical reaction, so that cohesion takes place while they are in the molten state, *without the mechanical pressure*. This process found a wide application in the repair of broken steel parts on the railroads and the saving which resulted from its use, without doubt aggregated millions of dollars.

Welding with the oxygen and fuel gas flame was the first widely used autogenous welding process. In this case the heat for weldin\u03c3 is produced by the chemical union of oxygen and some fuel gas, such as acetylene. The gas flame as a tool in the railway shop is best described by the once fictitious term, "putting on tool." The parts to be welded are heated to a liquid state at their surfaces by the heat of a flame and the metal to be added is melted simultaneously. The union, or fusion, takes place and the metal in the joint cools off, leaving a homogeneous mass which we call a weld. Since every one is more or less familiar with the gas welding process, this paper will deal primarily with the electric welding process and an extended discussion of the gas process will be omitted. It is sufficient to state that at the present moment the essential difference is in the method of producing the heat for welding, rather than in the fundamental principles involved.

In passing it may be stated that there is a form of electric welding which is not an autogenous method of welding, but which is increasing in prominence in railway work. I refer to butt or spot welding work. In these processes both heat and pressure are used to produce the weld. The heat is produced by the resistance offered to the passage of an electric current through the pieces to be welded. The temperature is raised to the point at which the metals become plastic and the pressure applied. In principal the processes are identical to the forge welding process. Butt welding as applied to the safe ending of flues offers an attractive saving and will undoubtedly become standard practice on all railways in the near future.

There are two kinds of electric arc welding, known respectively as carbon electrode welding and metal electrode welding. In the former an arc is drawn between a carbon electrode and the piece to be welded and the metal to be added fed into the arc in the form of a "melt bar". This process is not used exten-

sively in railway work, due to the fact that welding may only be done in the horizontal plane in this manner and that the work is in general inferior to that which is possible with the metal electrode process.

The metal electrode process uses, as the name implies, a metal electrode—the arc being drawn between the electrode and the piece being welded. The heat of the arc melts the metal of the piece and the metal of the electrode simultaneously. As the metal of the electrode melts it is drawn across the arc to the molten metal of the piece where a complete and homogeneous union is formed, which we call an autogenous weld. I say the metal of the electrode is *drawn* across the arc rather than that it falls through the arc advisedly, since it will flow straight overhead as well as straight downward. The temperature of the arc is extremely high at its center, actually vaporizing the metal to form the visible arc. With the exception of work with certain electrodes (manganese steel and slag-covered electrodes), the electrode is always made the cathode or negative—that is, the current of electricity flows *from* the piece being welded to the metal electrode. The reason for this practice is that the greatest amount of heat in an electric arc is liberated at the point at which the current passes from the solid medium to the heated vapor of the arc. Since the metal of the piece has more mass and conducts the heat away from the point at which the welding is being done more rapidly than the electrode, it is desirable to have the greatest amount of heat on the piece. Due to the composition of the manganese and slag-coated electrodes, it is necessary to make these electrodes the positive.

The characteristic of the wire which is used for the metal electrode is an important matter. A dead soft steel wire has been found entirely satisfactory for this work. Not all dead soft steel wire, however, works well in the arc. Uniform mechanical treatment in manufacture and careful annealing are required to secure the best results. This wire can be secured at the present time at a cost ranging from approximately 6 to 10 cents per pound. Good welding wire may be relied upon to give metal in the weld which has a tensile strength of from 50,000 to 55,000 pounds per square inch. The deposited metal is very soft and easily machined, although it is without appreciable elasticity. When properly deposited, the metal is practically free from blow holes and slag inclusions, although a certain amount of oxide in solution is unavoidable. Except for the absence of elasticity, the deposited metal is of the nature of cast steel

The voltage required for metal electrode welding is approximately 20 volts and direct current power is necessary. The various types of welding equipment are merely different plans for rendering available a rather heavy current at this voltage, and the power economy of the several systems for obtaining this result varies over a wide range. Since we have gone into the matter on a rather extensive scale on the Rock Island Lines, it may be of interest to analyze briefly the conditions which led us to decide on a certain type of equipment.

A little over five years ago, the Rock Island installed four electric welding units of the first type that had been manufactured in this country. During the time since their purchase, and up to the present, we have been quietly investigating and developing our electric welding practice. As a result, we found that to obtain a suitable welding system it was necessary that we secure a light, compact, portable unit, of few parts, and of extreme simplicity, which would be entirely free from complicated mechanical regulating devices.

In planning the installation, a careful analysis was made of the service which is demanded of electric welding equipment in railroad shops and engine houses, and an attempt was made to design an installation which would show under such conditions maximum reliability and flexibility with minimum installation and operating expense. It appeared certain that the welding process would find a wider field of application than was apparent at that time, and the installation was made in such a manner as to lend itself readily to enlargement should that become necessary. And I might say here that in view of our experience and results we were indeed fortunate in rendering an expansion of the welding facilities easy. The lack of standardization of operations in the practice at that time made it extremely difficult to predict accurately the size of installations which would be required at the various points on the system, so it appeared desirable to install equipment which could be moved from one point to another, until proper distribution could be obtained.

It was considered particularly desirable to have the arc welding equipment available at all points in the shops and engine houses, since it was quite evident that the advantage of the low cost of the arc welding process would be lost if, for instance, the locomotive had to be moved from a haphazard location to a point where the welding power

would be available. These features led to an analysis of distributing systems for the welding power and showed the necessity of using portable arc welding equipment, similar, so far as possible, to the portable gas welding outfits. With the total capacity divided at each shop among several units, it appeared certain that so long as power was available, there would not be a complete shutdown of the welding equipment. Each operator would be entirely independent of the others, although as many as necessary could be concentrated on any engine or job in the shop.

The operating economy, while not a deciding factor, was important, since at some shops the power plants were loaded to their capacity, and at other points the power purchased from small central stations was rather high. Under these conditions, the variable voltage type of equipment was considered the best because this type eliminated the resistance ballast from the arc circuit, thus increasing the power economy of the units to such a degree that a single operator unit may be operated from a power line large enough to carry a five-horsepower motor.

As a result of the analysis of the requirements of the shops and car repair yards, 33 individual unit welders were installed, 10 of which were mounted on brackets on columns in the largest locomotive shop, while the other 23 were portable machines weighing complete with truck approximately 1,700 pounds. All of these units are motor generators having inherent regulation and an arc stabilizer. The portable units are equipped with ball bearings which require lubrication about once in six months. Part of the machines are equipped with 230-volt direct-current motors and part with 440-volt three-phase, 60-cycle motors, these two kinds of power being the standard on the Rock Island Lines.

I might say in passing that at the time we purchased the portable equipment the manufacturers of the welding outfit were only able to furnish a standard industrial truck for this purpose. We have since found from actual practice exactly what is required in this line and are developing a standard truck which meets the requirements much better than an ordinary industrial truck. One of the manufacturers will shortly offer this development on the market as standard equipment.

The portable unit system was found to be from 30 to 40 per cent lower in total initial installed cost due to the elimination of the low voltage distributing system.

With a system such as has been installed on the Rock Island Lines, with portable welders, the installation of electric welding equipment is converted into a system proposition rather than a series of plants to take care of certain shops or terminals. The plan is extraordinarily flexible and has many desirable features that would be impossible to obtain with any other plan or type of equipment. For instance, if it is found that one or more welders are needed at some shop, it is very probable that some can be transferred from another point which has more than can be used to advantage at that particular time, it is only necessary to pull the units to be transferred into a car, block them substantially, and bill to the point where needed. Immediately on receipt they are ready for operation. We have taken advantage of this feature of the plan on a number of occasions and have been able to relieve congestion of work and get engines into service considerably ahead of the time originally estimated. However, officials at all points are very reluctant to surrender any of their welding equipment, claiming that they have not nearly enough as it is.

We have succeeded in making the application of the electric arc welding process on the Rock Island Lines a system proposition not only in the matter of the apparatus itself but also in its operation. It appeared to us that some roads were using the process in a more or less haphazard manner, leaving the matter to the fancy of the operator. It seemed to us that in going into the practice it would be advisable to throw the whole force of the operating organization into it to get the most out of it. The successful application of the process requires the combination of three factors—engineering knowledge, craftsman's skill, enthusiasm. The direction of the practice on our road rests with the engineering staff of the mechanical department; the actual operation is done by skilled members of the boilermakers', pipefitters', machinists' and blacksmiths' crafts. We do not employ novices or apprentices in this work. Only the best men of the respective crafts are picked for operators. It has been plain from the start that only the highest type of craftsmen could secure the results we want and we have witnessed the growth of a considerable amount of pride and enthusiasm in the work among our operators. Even with the best of equipment and facilities for welding, we recognize the fact that it is absolutely necessary that only skilled operators be employed.

Under competent direction, the skilled and enthusiastic operator will seldom make serious blunders in the application of the process. We have found few of the "know it all" type of men among our skilled craftsmen in this work, whereas I am quite certain some roads have had great difficulties in this line among operators made of green apprentices and "handy men". Further, we have found that the skilled craftsman, who is enthusiastic about the process, is continually finding new and profitable fields for its application.

The connecting link between the engineering staff and the operators is the Supervisor of Welding, who is fully informed on the range of approved applications and is also the most expert operator on the road. He is continually traveling between the shops keeping the practice of each up to date and seeing that everything runs smoothly. The operators at local points are under the supervision of the foremen and master mechanics in exactly the same manner as lathe operators or other craftsmen.

Due to the shortage of time, it is not within the scope of this paper to discuss in detail the necessary instructions for properly operating a complete welding system. On the Rock Island it was found essential that we compile a complete set of welding instructions, which comprise some 30 typewritten pages. It is the purpose of this set of instructions to standardize the major operations as far as possible. The extreme range of the application of the process has made it quite impossible, up to the present time, to standardize every single operation, but these instructions cover the field in such a general way that the operator is prevented from making serious welding blunders. In view of the fact that our practice has been so rapidly developed by this method, it will be necessary, this fall, for us to revise and reprint our standard welding instructions, which at that time will be very complete. Let it suffice to say that the ability of the operator to make good welds requires that he have some knowledge of metals and their properties, especially as regards expansion and contaction, and that his education by the supervisor be thorough and complete. It is now evident to us that the complete instruction and training of the craftsmen in the art of electric welding should be considered as a necessary additional course to the apprenticeship they served when learning their trades, in order to keep pace with the rapid strides being made today in mechanical engineering practice. It is the desire of the writer and the intention of this paper to more fully acquaint the railway management with the economic value of the new welding process, both in war and in peace, in order that it may be given the great attention that it so well deserves.

The actual results of the operation of the welding equipment and the welding system on the Rock Island Lines have proven very interesting. We have recently undertaken a rather extensive investigation of what the results are, and I am giving below some of the figures we have obtained as a result of about six months' operation of the complete system. The real answer to the question of whether or not the expenditure of some $40,000 for the installation of the system was justified lies in the actual facts—reduction of maintenance cost and actual gain in engine days with our present equipment. In other words, the object of the investigation was to determine whether or not we are saving money by the operation of the system, and whether or not we are actually getting more transportation service out of our motive power and rolling stock equipment. The following table shows some actual figures on the cost of repairing a small number of representative locomotive and other parts (for which we were able to obtain costs at a reasonable expenditure) by the gas and electric method, as compared with the old method, which in many cases involves a complete replacement of the part. It is indeed unfortunate that the railways have not kept detailed costs of the work necessary to the operation of the property. As compared with the old method, the saving of the electric process arises principally in the saving in labor. As compared with the gas process, the electric welding offer a saving in the cost of producing heat and an appreciable saving in cost of labor. It seems to me that under present conditions, and possibly under conditions which will obtain in the future, the labor saving is the most important item. It is evident from the figures that an important saving has been made. In other words, the operation of the process in our shops may be said to have rendered each man more effective, and has en-

abled each man to accomplish more toward the maintenance of our equipment with the same amount of effort. It seems to me that in view of the present labor conditions, which involve principally the very serious shortage of skilled labor, this is quite an important matter.

COMPARISON OF ELECTRIC WELDING VS. OLD METHODS AND GAS WELDING

Description of Parts	Cost Old Method	Cost Gas Welding	Cost Elec. Welding	Saving Over Old Method	Saving Over Gas	No. Engines
Valve stems..............	$ 16.28	$ 15.26	$ 4.76	$ 11.52	$ 10.50	6
Eccentric straps.........	17.95	7.63	2.38	15.57	5.25	2
Cylinder cocks..........	1.36	1.04	.34	1.02	.70	1
Cross heads.............	356.40	120.23	37.73	318.67	82.50	13
Piston heads............	47.93	32.74	10.24	37.69	22.50	4
Motion saddles..........	8.32	10.94	3.44	4.88	7.50	2
Frame braces...........	99.50	48.00	15.00	84.50	33.00	10
Crank arms.............	18.81	26.14	8.14	10.67	18.00	5
Rocker box castings......	4.59	7.29	2.04	2.55	5.25	1
Transmission bar........	2.80	4.38	1.38	1.42	3.00	2
Reach rod...............	1.25	1.09	.34	.91	.75	1
Rocker arms............	20.75	13.24	4.24	16.51	9.00	6
Engine truck equalizers.	7.70	17.24	5.24	2.46	12.00	2
Truck frame............	15.70	13.04	4.04	11.66	9.00	3
Trailer jaws............	2.76	4.38	1.36	1.40	3.02	1
Extension piston cross head..................	6.30	4.36	1.36	4.94	3.00	1
Brake beams............	1.69	2.18	.68	1.01	1.50	1
Brake hangers..........	5.10	7.45	3.40	1.70	4.05	3
Smoke arch brace.......	3.50	6.25	2.14	1.36	4.11	1
Air pump valves........	2.50	1.33	.53	1.97	.80	1
Lugs on valve yoke.....	32.45	21.80	6.80	25.65	15.00	6
Push car wheels.........	6.00	10.56	3.05	2.94	7.50	4
Stilson wrench..........	1.60	1.09	.34	1.26	.75	1
Drill chuck.............	15.00	2.18	.68	14.32	1.50	1
Driver brake fulcrum....	5.52	8.72	2.72	2.80	6.00	1
Wheel spokes...........	1,276.80	113.08	35.08	1,241.72	78.00	15
Main rod blocks........	15.88	28.34	6.84	7.04	19.50	9
Triple valve gauge......	20.00	3.27	1.02	18.98	2.25	1
Link blocks.............	72.24	51.49	15.49	56.75	36.00	20
Lift shafts...............	23.98	4.02	1.02	22.96	3.00	1
Quadrant	7.43	11.09	3.59	3.84	7.50	3
Wedges	55.04	69.69	21.69	33.35	40.88	25
Chafing castings.........	8.30	10.70	3.20	5.10	7.50	1
Plugging and building up holes	349.69	280.94	140.47	209.22	140.47	70
Tire rim keys...........	3.22	5.38	2.38	.84	3.00	2
Throttle stem...........	1.50	1.09	.34	1.16	.75	1
Reverse lever support...	3.38	4.36	1.36	2.02	3.00	2
Smoke box..............	61.38	32.43	9.93	51.45	22.50	2
Hub liners..............	12.51	13.11	4.11	8.40	9.00	3
Strip on cross heads.....	25.32	31.00	12.66	12.66	18.34	3
Fire door handle........	1.75	1.09	.34	1.41	.75	1
Boiler casings...........	63.21	30.30	9.32	53.89	20.92	1
Frame buckle...........	4.90	2.41	.91	3.99	1.50	1
Trailer yokes...........	5.25	6.45	1.95	3.30	4.50	1
Motion frame...........	9.10	10.17	4.17	4.93	6.00	1
Combination lever.......	1.03	1.75	.55	.48	1.20	1
Lugs on trailer hub.....	4.50	4.52	1.52	2.98	3.00	2
Center Castings.........	76.81	28.56	9.06	67.75	19.50	3
Spring blocks............	1.15	1.09	.34	.81	.75	1
Guide blocks............	5.52	4.29	1.29	4.23	3.00	1
Binder	5.19	13.10	4.10	1.09	9.00	2
Steam pipes.............	3.79	5.12	2.12	1.67	3.00	1

Flat spots on tires......	99.86	95.77	29.77	70.09	66.00	4
Cylinder bushings.....	35.65	9.40	3.40	32.25	6.00	1
Building up side rods....	93.48	81.16	31.16	62.32	50.00	2
Grease cups.............	11.79	11.43	3.93	7.86	7.50	5
Stationary fire door.....	8.00	8.72	2.72	5.28	6.00	1
Cracks in tanks.........	372.69	113.62	35.16	337.53	78.46	14
Petticoat pipes..........	140.52	52.37	16.37	124.15	36.00	18
Filling worn spots......	2,677.80	1,064.60	329.60	2,348.20	735.00	128
Pins	70.66	87.23	27.23	43.43	60.00	27
Reverse lever parts.....	103.02	74.04	23.04	79.98	51.00	38
Total	$6,434.10	$2,755.74	$921.61	$5,512.49	$1,834.13	

COMPARISON OF ELECTRIC WELDING VS. OTHER METHODS

Parts That Cannot be Welded by Gas

Description of Parts	Cost of Other Methods	Cost of Elec. Weld	Saving	No. Engs.
Pedestals	$ 645.00	$ 45.24	$ 599.76	5
Tank frames............	9.03	1.36	7.67	1
Shop tools	34.36	3.40	30.96	4
Piston rods	78.64	16.37	62.27	10
Sharp flange drivers............	165.40	20.28	145.12	3
Truck side	194.00	10.20	183.80	4
Building up dr. axles............	121.50	4.90	116.60	1
Steel car underframe............	11.34	1.71	9.63	1
Building up car axles............	315.00	25.24	289.76	..
Bushing staybolt holes............	294.96	73.74	221.22	26
Welding flues	2,607.65	521.53	2,086.12	102
Frames	931.00	133.28	797.72	11
Cracks in the fire boxes............	2,431.27	297.17	2,134.10	92
Total	$7,839.15	$1,154.42	$6,684.73	

SUMMARY

Costs and Savings—Per Month

Cost of Other Methods	Cost of Gas Welds	Cost of Electric Welds	Saving Over Other Methods	Saving Over Gas Weld
$6,434.10	$2,755.74	$ 921.61	$5,512.49	$1,834.13
7,839.15	3,697.42*	1,154.42	6,684.73	2,543.00*
$14,373.25	$6,453.16	$2,075.03	$12,197.22	$4,377.13

Costs and Savings—Per Year

$77,209.20	$33,068.84	$11,059.32	$66,149.88	$22,009.56
94,069.80	44,369.04*	13,853.04	80,216.76	30,516.00*
$171,279.00	$77,437.88	$24,912.36	$146,366.64	$52,525.56

Our figures show that the saving effected by the electric arc welding system is being made at the rate of approximately $200,000 a year with our present equipment. This figure includes a direct saving as compared with other methods of about $136,000. The saving arising from the fact that we keep the engines in service a greater proportion of the time makes up the balance of the figure. Our figures show that this saving is being made at the rate of about 1,400 engine days per year.

Another way of looking at the same matter is that by the operation of the electric welding system we have obtained the service of four additional engines, without the additional investment, beyond that required to install the welding system. Four additional engines are worth approximately $200,000. The welding system installed complete cost about $40,000. The cost of operation of the system for a year is approximately $34,000. Figuring the value of the engines at $40 per day, we will pay

*Figures show cost of gas weld if work could have been welded with gas.

for the operation of the whole electric welding system and will clear $22,000 from this feature of the operation of the electric welding system alone. However, we made important savings, as are shown in the preceding table, in the repair of parts on engines, where we could not show an actual gain in engine days of service, and this saving amounts to more than twice the saving arising in the increase of the number of engine days of service we get from our equipment. The net return secured on the electric welder investment amounts to approximately 500 per cent per annum. The net cost of the installation and equipment per unit under present conditions is approximately $1,300. The foregoing figures show rather conclusively that the installation of the electric welding system has been a profitable investment on the Rock Island Lines.

In spite of the fact that we have probably a larger number of operators than any of the Western roads, we believe that we are far from fully equipped. The field of application of the process is continually widening. We are not able at the present time to handle all the operations which we have demonstrated to be practical and profitable. There is a totally unexplored field in maintenance of freight and passenger cars, which promises to eclipse in importance maintenance of motive power. There is a field in the repair of special track work which we have not gone into up to the present time.

The present indications are very strong that when we go fully into the electric welding process in fire box, boiler, locomotive, machinery, steel tanks, car work, track work, etc., that we can well use 150 units and effect a net saving, as I have stated before, of approximately $1,000,000 a year. Within the last three years the arc welding process has been greatly improved and developed, both in the equipment for making the weld and in the welding material. It has, in fact, been developed to such a state that it will no doubt cause changes in many forms of construction, and the welding of fire boxes, tanks, etc., will become an economical practice. In fact, it is in the car field of construction and maintenance that we may look for a wonderful development. For instance, today the cast steel truck side frame will last almost indefinitely where the electric welder is used in maintenance. Also it is as a preventative that the electric welder has a great field by the intelligent application of spot welding with the electric arc. It will, no doubt, be possible to tie down bolts and nuts in the various parts of the rolling stock and motive power in such manner as to prevent their working loose, with the attendant very large saving in maintenance and operating expense. Quite recently we have been able, by using what is called a slag-coated electrode, to deposit steel having a carbon content of 0.50 per cent which will enable us to do some work which we have been unable to do heretofore. We can successfully take care of the worn or damaged flanges of driving wheels, and should be able to reclaim much of the special work and rail steel by successfully building up the worn parts or broken sections.

It has been our purpose in establishing the practice in the welding field to look the facts squarely in the face and apply either the gas or electric process, depending on which shows the best results at the lowest price. At the present time we are of the opinion that the electric process will supersede the gas process on all steel welding and some of the rough steel cutting. In the cutting of boiler steel and all close cutting, however, and the welding of cast iron and the non-ferrous metals, the gas process has unequaled advantage.. We are operating 75 gas torches and one acetylene generating plant on the some general principle as obtains in the case of the electric arc welding equipment. It is also best to use gas welders at all points where only occasional welding is done and which would not justify the investment necessary for the installation of electric welder.

While we have not been able to meet the suggestion of the American Railway Association's special Committee on National Defense, which reads as follows: "About 15 per cent of locomotives are ordinarily under repair. If this percentage were reduced to 10 per cent, which figure has been reached by some roads, it would mean an addition of 3,325 locomotives to the number in service," we have been able to move in that direction and have nearly reached the figure of 10 per cent, and at the same time added to the profits of the road by our welding system. It is our belief that with approximately five times the amount of electric welding capacity we have at present, we can show at least five times the annual net saving, which would amount to a million dollars a year, and that we can with this equipment in operation show a saving of around 7,000 engine days per year, which means that we would be able to secure from our present engines a mileage that will equal that which could otherwise only be secured by the purchase of 23 additional engines.

With this figure in mind, and know-

ing that the Rock Island Lines have approximately 1,600 locomotives in service, it is easy to realize the enormous possibilities in the direction of increasing the service from motive power equipment on the combined railway systems of the nation, both as an economic proposition and as an aid in war, were they all equipped with welders. The demand for transportation service is so urgent, and the effectiveness of the nation in this war depends so directly upon the quantity of service which may be rendered, that it seems imperative that the railroads should go into the welding field on a large scale at the earliest possible moment. These figures have been given with particular reference to motive power units. While we have no tangible data on what may be accomplished in the rolling stock field, it is our belief, from the preliminary survey of the situation, that even a greater gain can be made toward keeping the equipment in service in this field than has been made on the motive power units.

The application of the new welding processes is important now as never before, when every railroad must get the maximum of service from all of its equipment; when the nation demands the supreme effort of the transportation system of the country.

What I have just said refers particularly to railroad work and gives some idea of what we think can be accomplished, using as a basis for estimation the results we have actually accomplished on the Rock Island Lines. The enormous possibilities, however, in the application of the new welding processes to other fields are of absorbing interest in view of the present world conditions as a result of war and their effect on labor and material. Not least among the possibilities of the welding processes is that of substituting welding for riveting in bridge and building steel construction. These structures are permanent, and knowing the safety of the welded joint, from our experience with boiler work, etc., we can safely prophesy that such structures will be welded in the future in place of being riveted, from the standpoint of both economy and safety. This is a new idea, but when we consider that five years ago the complete welding of a locomotive fire box was considered an absurdity, the newness of the idea of welding steel structures is not in the least appalling.

The possibilities in the field of ship construction and repair have been explored to some extent. Every harbor on the Atlantic coast and the large harbors on the Pacific coast are all equipped with the apparatus. Up to the present time the welding, however, has been entirely on repair work, but the savings effected by the use of the process on boiler repairs, repair of broken stern posts, rudder shoes, propeller shaft sleeves and miscellaneous superstructure work, have been important and enormous savings have been made. It is sometimes possible to make necessary ship repairs in one day with the electric welder that otherwise would have required two weeks, and since the value of a ship at sea per day ranges anywhere from $500 to $2,000, it can readily be appreciated that there is an enormous demand for the work at the present time. The commercial welders in the Atlantic ports charge from $10.00 to $20.00 per hour for the services of one man, which is a very good indication of the fact that the application of the process is valuable to the steamship owners. It is the understanding that at the present time the British Admiralty is welding in place of cauking on torpedo boat destroyer hulls, which practice permits the hull to offer much greater resistance to shock of collision, shell fire, or torpedo destruction. It is reasonable to assume this practice will be extended to our navy and merchant marine in the welding of ship's hulls. Already several of the shipbuilders on the Atlantic coast have made application for patents on the completely welded hull, and while no actual construction of this nature has been done as yet, it is probable in the near future that we shall see the completely welded hull in service.

The extensive application of the arc welding process in the United States has led other countries to the adoption of the improved practice. Notable examples of this are the introduction of welding outfits into the principal harbors of South America. In the German and English naval engagement off the Falkland Islands, the British ships were severely damaged and put into a South American port for repairs, where they commandeered a marine electric welding outfit, immediately putting to sea and effecting their repairs in a comparatively short time; thus their ships were ready again for service in a much shorter time than would otherwise have been possible, when every minute was very valuable indeed. The electric welding equipments were extensively used in repair work during the construction of the Panama Canal. The South American Railway Corporation and some mining corporations are installing the portable equipment manufactured in this country. A Japanese government expert has re-

cently returned to Japan with complete information and the introduction of the process will probably be rapid in that enterprising country. Already a considerable amount of equipment has been shipped to Spain, Norway and Sweden for use on railways and in steel foundries.

Four portable electric arc welding units such as are in use on the Rock Island Lines are now being shipped to the French fighting front for use on military railways by the "American engineer regiments (railways)." The application here covers not only the standard gauge railways which transport ammunition and supplies to the front lines, but also in the construction and maintenance of narrow gauge feeder and trench railways, the tracks of which are ordinarily constructed of small steel rails which may be welded to the steel ties, these railways being of a portable type. There are also a very large number of automobiles, motorcycles, etc., to be repaired, as they are constantly breaking down, due to the extremely strenuous service in which they are employed. In fact, without the use of the gas and electric welders, the life of such equipment would be very short indeed, when used at the battle front. Within the last year we have seen the increasing use of the English tanks, which call for very extensive repairs, that can be most efficiently made with the electric welder. The artillery also makes a heavy demand on the welders for repairing gun carriages, gun mechanism and the guns themselves. It is necessary on the front that these repairs be made expeditiously under most trying conditions—conditions that it would be practically impossible to meet were it not for the autogenous welding devices.

A little to the rear of the actual fighting front, the electric welders are in demand for repairing horse equipment, including the repairing of vehicles, and it is thought that in the near future it can be used for welding new calks on the horse shoes to replace those that are worn, without the necessity of removing the shoe from the horse's hoof. The strenuous military campaigns require frequent demolition of iron and steel structures, including heavy guns, and the electric and gas cutting processes have been found extremely valuable owing to the great speed at which iron or steel structures may be demolished beyond the hope of repair.

In many instances there is a source of electric power supply from the power lines that run in or through the theater of war. However, in some instances where no such lines are encountered and for some reason or other it is not possible to hastily construct a power line, it becomes necessary to set up a small internal combustion, power-driven unit in order to secure an electric power supply, which is becoming a necessity in modernized warfare. Electric welders can be used for trench lighting and searchlight work as well as for welding, which makes them very valuable equipment. One of the particular advantages in using the electric welder is that it eliminates the necessity for transferring welding gas, which would many times be practically impossible.

From the foregoing we may draw the conclusion that both the electric and gas welding processes are proving themselves one of our strongest allies, both at home and at the front, in fighting to victory and to world democracy the war that is now upon us.

The final result of every effort must be to put effective fighting men in the field because it is increasingly evident that the war will be won by the men who go over the top and put the enemy out of business, by exterminating him. It is easy to lose sight of the fundamental facts in this connection by a lot of superficial talk about the economic side of war. We are so far removed from the active fronts that it is easy to lose ourselves in a lot of talk about industrial economics and about how food will win the war, how locomotives will win the war, how sugar will win the war, how torpedo boat destroyers will win the war. It is easy to forget that it is actually the fighting man-power we can bring to bear upon the enemy that will really be the deciding factor. We must have the greatest possible industrial efficiency that can be obtained regardless of cost, regardless of the effort required to obtain it, and the reason is that we have fighting men on the front who must have everything that is required to keep up their morale and keep them in the very highest degree of effectiveness. Industrial efficiency is a part of our job, a necessary part of the nation's job of backing up the armed forces in the field. The big job is done by the men

who go over the top or over the seas and exterminate the enemy.

Another interesting application of the electric arc process is in the repair of the ships. Every ship that is seaworthy is in service at the present time, and time for repairs must be cut to the irreducible minimum. The electric arc process is used extensively for boiler repairs and repairs about the deck and superstructure. It is not unusual to make repairs to a ship's boiler with the electric arc process in 24 hours while a ship is unloading her cargo which otherwise would require a week to ten days to make and 50 times the cost. The use of the oxy-acetylene and the electric arc processes on the ex-German ships which were badly smashed up by the Germans, allowed these ships to be put into the service of the United States from four to six months sooner than would have been possible otherwise.

In the steel foundry the electric arc process is used to repair defects in steel castings which would otherwise make the casting useless. At the present time, the demand for steel castings for the government is greater than all of the steel foundries of the country can supply. The labor conditions in this industry are generally in such condition that it is impossible to get sufficient highly skilled labor to make perfect castings. The net result of the use of the welding process is to get the same output of castings as if all the men were skilled craftsmen.

The electric arc process is being used in boiler shops to replace riveting, a seam may be welded cheaper than it can be riveted and the joint is stronger than it is possible to obtain with the riveted construction in making a joint. One man with an electric arc will do as much work as a riveting gang of four men and the electric power required to operate the electric welder is about the same as the power required to run a pneumatic hammer.

Another interesting application in the process is in oil refineries where it is used both in addition to riveting and in place of riveting. On some of the large stills whose operation must be as nearly continuous as possible, the riveted joints are welded instead of being caulked. Such a joint is stronger than the original plate and the life of such a still is more than doubled.

DISCUSSION

A. W. RAY.—Can dissimilar metals be welded successfully, like cast iron and steel?

ROBERT E. KINKEAD.—Cast iron and steel may be fused together, that is, so far as the technical definition of a weld is concerned. The metal electrode process can be used to deposit steel on cast iron, and the union between the steel and the cast iron is good, that is, it is a fusion. But the difficulty we encounter in the work is this, that the steel when it is molten, is molten at the same instant the cast iron is molten. The cast iron is high in carbon. Molten steel has a very great affinity for hot carbon. It is said among the steel men that molten carbon is about as soluble in molten steel as salt is in water. The net result is that the molten steel absorbs the carbon, and we get high carbon steel on the steel side of the weld. We have a line of fusion; one side is steel and the other cast iron. On the cast iron side we have heated a very small area of the cast iron up to a molten state; there is quite an amount of metal back of it. It is cooled suddenly, almost as quickly as if you had melted the metal and dropped it into a bucket of water. On the cast iron side you have quenched cast iron, which is almost as hard and brittle as glass. On the steel side we have high carbon steel, which has also been quenched. So that on the line of fusion we have two kinds of metal, both of which are very hard and very brittle, so that such metal is rather unreliable. It

will not stand any dynamic stress at all.

A. W. RAY.—How about brass and cast iron?

ROBERT E. KINKEAD.—Brass has zinc in it, and anything that has zinc in it is almost impossible to handle with the arc. We effect such a high temperature with the arc that the zinc is volatilized immediately, and the thing burns up in white smoke. Copper and steel go together very nicely; you can make a beautiful joint. At the high temperatures there seems to be an affinity between the copper and the steel, and after the joint is made and you cut it you have a perfect joint.

Bronze that has no zinc in it can be welded. The welding of cast iron with the carbon arc process is entirely practicable. Some very fine work has been done with it. It is just like the oxy-acetylene. The difficulties encountered in the welding of cast iron are not due to the *welding* of cast iron—it can readily be welded—but due to the expansion and contraction strains it may crack and the weld, if it is not properly cooled, is apt to be hard. Take a piece of cast iron, of a complicated shape, unless you heat it up properly and slowly, you expand it at one point too much and it will crack. Assume that you have it properly pre-heated—brought up to an even temperature all over—then you make the weld. Now, if you cool it suddenly and unevenly, it is likely to crack. If you cool it suddenly and cool it all over at the same time, it is apt to be hard, chilled iron. If you weld without pre-heating it, and you get by without any cracks due to expansion and contraction, and the weld cools suddenly, you will have a hard metal you cannot machine. So that the welding of cast iron is a rather difficult matter with any process.

J. C. GILLETTE.—Is there practically no difference in the welding of cast iron with the carbon arc and the oxy-acetylene in the general treatment and handling?

ROBERT E. KINKEAD.—No, very little difference; somewhat more difficult to handle with the carbon arc than it is with the acetylene, I should think. There is one case where we have difficulty handling it with the carbon arc, and that is where we have a thin section. For instance, there is a great deal of work done on broken automobile cylinders. We have never handled that successfully, due to the fact that the carbon arc applied to such a thin section will go through before you can get the weld made. We have greater heat. The arc is not like the oxy-acetylene. They can back off and reduce the temperature. When we back off, the arc goes out. There is some work being done, using the metal electrode process, and using a cast iron electrode instead of a steel electrode. Pre-heating the cast iron promises a good deal, but I am not able to report any great degree of success because it has not been tried very thoroughly. I believe you understand that the electric arc process is practically in its infancy, still there are possibly seven or eight hundred outfits in operation in this country. Probably 90 per cent of that number have been put in operation in the last three and one-half years.

J. C. GILLETTE.—Are not those almost entirely in boiler and sheet steel works?

ROBERT E. KINKEAD.—Yes, and steel foundries; that covers a wide range of industries, and if you say forgings, malleable castings, steel castings, sheet steel and boiler plate, you will probably cover it pretty thoroughly.

J. C. GILLETTE.—The electric arc welding process is not as well adapted for the manufacturing plant for general repair work where you may get a broken casting, or for cutting miscellaneous stuff, as is the acetylene process?

Robert E. Kinkead.—I should not say so. When a manufacturing plant wants a welding outfit to make its own repairs on broken machine parts, and there is not enough work to keep a man busy more than half of the time, I should say the gas process is better.

F. W. Thomas.—Is the electric arc displacing the thermit weld to any great extent in heavy work, such as locomotive frames and rudder frames for ships, and such as that?

Robert E. Kinkead.—I believe it is. In railroad shops where they have the electric process, after they have had it in for a few months, they use it in nearly every case in preference to the thermit. The thermit process is a mighty fine welding process. The reason they use the electric instead of the thermit is because they can do the job at less cost. The welded piece is made thicker through the welded section than was the original. The reason for this is that if there is any bending to take place we want it to take place outside the weld because we know that the weld would not stand very much bending. That principle is one which holds good in all electric welding. We know we have enough tensile strength if we make it just the same thickness, but in order to give the joint resistance to bending we make it stiffer, make it thicker.

W. H. Burrage.—Can you cut with your arc process, that is, cut out a notch?

Robert E. Kinkead.—Metal can be cut with the arc. We do not do so as a rule, because the cost of providing apparatus for the job of cutting is out of proportion to the advantage gained, and you can cut faster with gas.

The building-up operations are the most interesting phases of electric welding or oxy-acetylene welding, for that matter, or of any autogenous welding. The steel casting in days gone by usually would not live out its natural life, and it would go to the scrap pile before it rusted, or before it went out of service from rust. It would either break or a hole would wear, and it would be shimmed up to a certain point, or bushed up to a certain point, and when you got beyond that point, you would say that the surface or several surfaces were worn out, and there was usually no way of fixing it up. An imaginary cubic inch of steel would probably go back to a steel foundry seven or eight times and be recast. Now we rebuild those surfaces. Take, for instance, a typical case—the side frame on a street car truck. That casting is subjected to all the hammering, knocking and wearing that you can imagine, perhaps the worst you can imagine unless it is a part on a locomotive. There is nothing that can happen to that casting that cannot be repaired in a very short time, and the casting put right back into service, for all practical purposes as good as new. It would seem to indicate that we will go more into the use of steel castings which can be treated in that fashion, because by welding we have saved the labor of scrapping the casting, transporting it back to a steel foundry, remelting it, casting and machining it, and bringing it back and putting it into service again. With our present methods we can repair the defect right on the job and put the thing back into service.

Now, in the building-up process, we can use either the carbon or the metal electrode welding. The metal electrode is used much more than the carbon. The reason is that the heating in the metal electrode process is localized. It is not a very good thing for a steel casting to heat it up and get it very hot locally and then cool it. It ought to be subsequently annealed. Heat up one section with the carbon arc, or the oxy-acetylene flame, and allow it to cool rather suddenly. You may produce strains in the casting that would interfere with its usefulness, and it is considered the best practice to anneal the

casting before it goes back into the service. Still, it is not always practicable to do that, not in the ordinary repair shops. So they use the metal electrode process. With the metal electrode process the heat is small in quantity and so localized that we do not produce the strains that is, the appreciable strains.

Q.—What is the minimum thickness of the sheet metals on which you work?

ROBERT E. KINKEAD.—We work on 1/16-inch metal, but on ⅛-inch and under we call it a special application. You cannot do much with metal ⅛-inch thick or less. Where it is too thin, say 1/16-inch thick, and you wish to weld a straight butt joint—butt the plates together and weld them—you have to have a heavy backing to carry the heat away, otherwise the heat of the arc will burn through. On 3/16-inch plate we do not need that backing.

Q.—Would that backing weld on to the joint necessarily?

ROBERT E. KINKEAD.—No, we use a heavy backing and we do not get it hot enough. The heavy backing will conduct the heat away fast enough so that the sheet metal will not weld to it.

Q.—It is not necessary to put any plate between?

ROBERT E. KINKEAD.—No, sir. There are certain conditions that give us some trouble, and in these cases we use a copper backing, and copper conducts heat much more rapidly than steel or iron. We have no difficulty whatever if we use copper backing.

Q.—What could you do with copper wire if you wanted to weld a joint, to make it ductile after you had welded it?

ROBERT E. KINKEAD.—I do not know the proper heat treatment for copper to make it ductile; to quench it, I believe, is the proper procedure.

Q.—But even that was tried without a great deal of success.

ROBERT E. KINKEAD.—It is cast copper after you get done with it, and it will never have the same properties that you get from drawn copper.

Q.—I saw them trying to weld the strands on an armature, and they could unite the ends all right, but they had difficulty in hammering them back into place in quite a number of cases.

ROBERT E. KINKEAD.—I have encountered this kind of problem. Take a million circular mill cable—places where you want a joint. Now, if you put a good, heavy, strong copper ferrule on each end, and make a little mould out of carbon, use the carbon arc and just merely run the copper into the mould, you get sufficient heat to melt the ends. A good joint can be made in this way, but if you try to do it without those copper ferrules, you will melt back the wire, and it is impossible to get a good job.

Q.—The copper ferrule unites with the wire?

ROBERT E. KINKEAD.—Yes, it will all run together. You will have simply a solid mass at the joint.

Q.—That is what we found, and we had four or five joints to make right beside one another, and it made such a bulk we could not get them back into the armature.

ROBERT E. KINKEAD.—I should say you would encounter trouble there. It would be a difficult operation. You would get a mass around the joint unless you had a very carefully made mould.

Q.—Can you cut cast iron with the arc?

ROBERT E. KINKEAD.—Yes. Incidentally, it is pretty well known that the gas process does not cut cast iron. It will not oxidize it. The gas cutting is an oxidizing process, but the electric arc merely melts a groove through and we have no difficulty whatever in cutting cast iron. However, if you want to cut a piece of cast iron and have to have it machine off smoothly, you have to treat it as if you were going to weld it. You

must heat it before cutting, then cool it slowly. If you take a piece of cold cast iron and cut it with the arc, when it cools it will be hard at the point where you cut it. You would have no trouble cutting high speed steel with the arc. There is no difficulty in cutting any metal with the arc because it is merely a melting process. You can melt any metal that is known with the arc. You can take a carbon crucible and a carbon arc, and throw concrete or stone or rock or anything into it that you want, and melt it up.

We can take a small piece of high speed steel and weld it to a piece of common carbon stock, that is, put a high speed steel point on a low carbon steel shank. It saves the scraps and makes a very good tool.

I was on an interesting application recently—a company which makes a special patented tool holder, was using Stellite, and they welded the Stellite to the common carbon stock, and then put them in a pre-heating furnace, brought them up to a very high temperature, put them in dies in a hydraulic press and pressed the welded joint together. It made a very fine joint, and the heat of the arc was localized enough so that it did not interfere with the quality of the Stellite. They had previously been using the contact welding process or the spot welding; and in welding it that way the heat of course operated on the Stellite and seemed to take some of its properties away from it. The localization of heat of the arc process improved the product considerably.

R. S. Mayer.—Do you get any oxidizing effect at all in the case of the arc?

Robert E. Kinkead.—Yes, the metal is probably considerably oxidized. The hot steel—molten steel—absorbs the oxygen from the atmosphere very rapidly. There is an electrode on the market which eliminates that. It is what is called a slag-covered electrode. In other words, this wire is surrounded with a lot of slag, mostly silicate, and it has an aluminum wire wrapped around it. That aluminum surface has a deoxidizing effect when the metal is molten, and the arc always operates under that slag, so that the oxygen from the atmosphere is partially excluded, and we do not get quite so much oxidation.

I am surprised that somebody has not asked me if the arc weld is as good as the acetylene weld. We used to think that the electric arc process was a serious competitor of the gas process, and the gas people thought very much the same way about us; but it seems that we can both live in the world together now. There are a great many places for both processes. There are a great many plants that ought to have both processes. Every railroad shop and a good many other shops ought to have both the gas and the electric. The result of rather impartial investigation shows that they get about the same results with both processes, that is, so far as welding is concerned. On thin sheets, it seems that with a gas weld you can bend it a little bit more than you can with an electric weld. When you get up into heavy boiler plate they are about the same. So far as skill is concerned, probably about the same amount of skill is required to operate the electric arc as to operate the oxy-acetylene. The adjustment of the apparatus is a little bit simpler with the electric arc. There is not the matter of handling the gauges, etc., but the average operator we find in the industrial plant will get about the same results regardless of the process.

Q.—Do both processes require reannealing after welding?

Robert E. Kinkead.—On carbon electrode work, as applied to steel castings, it is almost universal practice to anneal a casting after welding. On metal electrode work it is not necessary to reanneal the casting. Most of the steel foundry work is done with the carbon arc. We use practically a standard machine for

that. It is of 400 amperes capacity.

Q.—Is there any difference in the result with a platinum point or carbon point?

ROBERT E. KINKEAD.—We have never used a platinum point. Metal electrode or carbon?

The metal electrode is used on small steel castings. For instance, electric steel, where the defect is very small, where you use a pneumatic tool and chip it out. If you have a sand spot, you cannot handle that with the metal arc, but if you have just a small defect that is chipped out and cleaned, you follow it up with the metal electrode. There are two places in general where we use the metal electrode in a steel foundry; one is the electric steel and the other is truck frames, railway castings which have just small defects. You get them just before the casting leaves the foundry. Take water wheel blades; there it is a matter of expansion and contraction. You cannot put a carbon arc on it because your expansion and contraction will give you trouble.

J. H. HALL.—In welding thin steel plates where a backing plate is used to carry away the heat, about how thin a plate can you work on?

ROBERT E. KINKEAD.—I would say 1/16-inch was the lowest practicable. It is practically a butt weld.

J. H. HALL.—Do you find it necessary to use a flux of any sort?

ROBERT E. KINKEAD.—No. Back in the game a long time ago, for the arc process, it was about six or seven years ago, it was thought necessary to use a flux. It was thought the flux would eliminate the oxidation of the metal. A number of other things were believed about the use of the flux, and it was considered necessary in welding. However, some very careful tests have proved very conclusively that flux does not have anything to do with it, that you will get oxidation just the same. The reason is that right at the end, where the electrode is melting and running on the flux runs off. It is not there when you want it. Another thing is that you can get such a small quantity on. It is painted on and you cannot get enough of it to stick. If you could get it on there it would be all right. The slag wire I have just talked about gets it on and it stays and accomplishes a very good result. But the difficulty is it has rather a limited application; it is rather difficult to handle. It is limited practically to straight downward welding.

If you had to weld a crack in the side sheet of a locomotive firebox after it had been chipped out you have a gap. With the slag-covered wire you cannot get in and fill the space; whereas, with the other, we can bridge across very easily. Another thing, in welding vertically the slag runs down and it is very difficult to handle. Now, in overhead welding we slip a thin plate—it need be only ⅛-inch thick, up through. That gives us something to weld up against. We cannot weld up against thin air.

Another thing is the welding of manganese steel. We can weld manganese steel such as is used in the cross-over work and special frogs and switches. We can put down a steel which has practically the same composition as the original—about 12 per cent manganese. In that case, strange to say, we switch around, as it works better if we use the electrode as positive and the work as negative. To tell you the honest truth, I do not know why, but it is a fact, nevertheless.

C. C. SMITH.—In that case you would have a 12 per cent manganese wire I suppose?

ROBERT E. KINKEAD.—Yes, sir.

Q.—In welding copper and steel together would you have to have a clean surface?

ROBERT E. KINKEAD.—Yes, the surfaces ought to be as clean as possible.

Q.—What length of time would it take you to weld copper and steel?

Robert E. Kinkead.—Well, it is pretty hard to say. It depends on the amount of metal you wish to weld. It is very quick. Have you any job in mind that has any particular size and dimensions?

Q.—Yes, rail bonding.

Robert E. Kinkead.—Well, I wonder if Mr. J. C. Lincoln would answer that question. Mr. Lincoln knows all about rail bonding.

J. C. Lincoln.—One rail bond can be put on in about 20 seconds for each head to the best advantage. You can make a better job than with any other welding or brazing process.

Q.—Carbon mold?

J. C. Lincoln.—The mold is a part of the apparatus that is required to do the work.

Q.—You were talking about overhead work. It seems to be pretty easy. I found it almost impossible.

Robert E. Kinkead.—In the overhead work, did you try a job that had been chipped out?

Q.—Yes.

Robert E. Kinkead.—Did you have the plate up above?

Q.—No, but I was using a very heavy electrode.

Robert E. Kinkead.—It takes more current to weld overhead than it does to weld down, run your current up to the point where your wire will just keep from getting red hot.

Q.—Yes, but it seems that the metal does not stick so well as when we are working on a flat surface.

Robert E. Kinkead.—It is worth a lot of anybody's time to see a man having a difficult job of overhead welding. Usually if he has not got a leather apron, when he welds overhead, the hot metal comes down and drops down in his overalls. As near as I can tell, the art of overhead welding lies in using a high current on the electrode and keeping it moving. Now, you cannot start another electrode until the weld has cooled. If it is red hot when you start another one, when you start up again you will have trouble; it will run away from you. But if you allow it to become cool enough so that there is no color and then start your next one, you will not have the trouble of its running away from you. If you work the job too hot, you will get trouble from the metal running down.

Q.—Is it good practice to weld around a heavy rivet instead of calking?

Robert E. Kinkead.—Yes, it is excellent practice. The heating is so local that it does not interfere with the rivets.

W. H. Brainard.—Perhaps you could tell me the error that was made in trying to weld a side frame on a street car truck. They were using open-hearth steel flux rods of about 0.12 to 0.15 of 1 per cent carbon. After the weld was completed it broke in the same place, and the break seemed to show a fine grain and very black fracture, more as if it had been burned than anything else I could imagine. Is it not possible to burn the steel with the electric arc?

Robert E. Kinkead.—I would not say it was burned. I am glad you brought up that term of burning steel in a welding process, because that term means a lot of different things to different men who use it. I do not think that the metal was burned in the sense that it was crystalized by the excessive heat. It was done with the arc process, was it?

W. H. Brainard.—Yes.

Robert E. Kinkead.—I think that the difficulty was probably due to improper placing of the metal. Was it a reinforced joint? That is, was it thicker through the joint than the original section?

W. H. Brainard.—It was built up slightly larger after it was finished than it was originally cast, but it seemed to have no strength. I am not a practical welder. I was just a bystander, and I grasped the idea that perhaps they worked too slowly and applied the heat for too great a period.

ROBERT E. KINKEAD.—Was it a complete fracture? Did it look as if there were points in there not welded?

W. H. BRAINARD.—Perhaps a spongy appearance, little bubbles in the weld.

ROBERT E. KINKEAD.—That is an indication of poor operation. The metal can be deposited in the joint so that the bubbles, there will be bubbles always, will be very small. There ought not to be any of them larger than a small pin head.

W. H. BRAINARD.—Some of these were as large as No. 2 shot.

ROBERT E. KINKEAD.—That would indicate that the metal was improperly put in. If an operator uses a long arc, that is, if he holds the electrode too far away from the work, the globules of metal come off, and they are apt to land any place, and the consequence is some of them land on the metal of the piece which is not molten, and therefore they will not weld. In order to make a weld, it is necessary that the globule of hot metal should drop on the molten metal of the piece. That is a test of welding. Most of the poor welding is done because an operator holds too long an arc. There is always one way you can tell; get a volt meter and put across his arc and you can tell. It ought to run around 20 volts. If it runs up, he is too far away.

J. H. HALL.—What class of work in general is preheated before the arc is applied?

ROBERT E. KINKEAD.—Cast iron. It is not necessary to preheat steel. The reason they preheat with the gas is to save gas. That is, if they want to weld on a large casting with gas, they will preheat it with a kerosene torch in order to save gas.

W. H. BRAINARD.—I understand it is in order to relieve the expansion and contraction strains.

ROBERT E. KINKEAD.—Well, in a steel foundry on some of the welds they make with a carbon arc, if they were not going to anneal the casting afterwards it would be advisable to preheat, but inasmuch as they are going to anneal it afterwards anyhow, the heating is not enough to produce a destructive strain. There will be strains left, but they will be taken out when it is annealed.

W. H. BRAINARD.—If you were going to weld a spoke in a cast iron wheel, would you have difficulty if the casting had not been preheated?

ROBERT E. KINKEAD.—Yes, sir, you would have all kinds of difficulty. Welding spokes in a wheel is a real job.

F. W. THOMAS.—How successful would that be in welding a break in a large spur gear, a break in the rim?

ROBERT E. KINKEAD.—All right. It would have to be preheated properly so that you would not break the thing while welding. Is it gray iron?

F. W. THOMAS.—No, steel.

ROBERT E. KINKEAD.—You would not have to pay any attention to it. If you welded it with the metal electrode process, you would not have to pay any attention to expansion or contraction.

F. W. THOMAS.—I had a case up north about a year ago in which a gear about 6 feet in diameter and about 5-inch face, cracked. It was an annealed steel gear, and they spoke of repairing it with the acetylene flame, and those that were operating it there said that it could not be done at all. I found out later that it could be done, but it was a rather precarious job. They said the teeth would most likely have to be filled with metal in that particular spot and then recut. This crack occurred between the arms.

ROBERT E. KINKEAD.—Welding gear wheels is a very difficult matter where you have to preheat, because if you get the job done wrong it is hard. Preheating is difficult in itself. There is a lot of miscellaneous preheating, and the commercial welders have acquired a great deal of skill in

that direction, without any science to speak of mixed up in it. A good craftsman looks at a job and figures out where it ought to be preheated and about how much. If his hunch is right, everything is fine; but the theory back of the thing is very simple. In your welding process, you are going to heat a certain number of cubic inches of metal to a certain temperature, and you know with a certain temperature that metal is going to expand so much, but if you are going to preheat some place else to a certain temperature to compensate for that expansion, you have got to heat so many cubic inches of metal in order to accomplish that result. If you get too much heat you are worse off than if you did not preheat at all.

In steel foundries when the process was first used, it was an indication of moral weakness. It was positively a sin to repair a defect in a steel casting with the electric arc process. It was argued that anyone ought to be able to produce castings that did not have defects, and if anybody repaired a defect he was a sinner. A good many sessions were held behind closed doors in the middle of the night while the inspector was at home asleep, welding defects in steel castings. We finally have come to the point where we can look the inspector in the eye and talk to him about the job; we are actually accomplishing something, and we are getting better results and more castings. It is a necessary part of steel foundry equipment now.

W. H. Burrage.—Can you with your control operate your current so that you could preheat your piece enough with the electric current to make it work?

Robert E. Kinkead.—Why, in steel foundry work sometimes we use the carbon arc to preheat around a difficult shape or a very heavy section where it is hard to get to; if you want to go deep down, if you have a deep sand spot to get down at the bottom and boil the sand out, we play the arc around until the defective area gets pretty hot before we go down in the hole to get the sand out. The carbon arc can be used for preheating. It cannot be used, however, on any piece of metal where the surface must be preserved, because in preheating you will melt the surface.

W. J. Oettinger.—In steel plate work do you always use a third piece?

Robert E. Kinkead.—No, there are only two cases where we need a third piece; one is overhead and the other is very thin, sheet work where we need backing.

W. J. Oettinger.—On sheet metal work is the third piece welded on?

Robert E. Kinkead.—No, it comes off. That is just a backing to keep the arc from burning through.

Now, in regard to the light of the arc. There are a lot of stories about the light of the arc burning your eyes out, etc. The truth of the matter is that the rays of the arc act just like sunburn. It will burn your eyes if you expose your naked eye to it. It will sear the outside of your eyeball. So far as we know, no one has ever received a permanent injury from the arc. It will make the eyes sore for about a day after careless exposure.

Electric Butt Welding

By J. B. Clapper*

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Electric welding, as distinguished from the old method of welding, is merely making use of an electric current in the heating of the metal parts to be welded together, the current producing no effect in the metal as to the quality of the weld, and so forth, other than the heating. Probably the first application of electricity in welding was made in the year 1881, it being recorded that an electric arc was used in uniting the parts of storage battery plates. The piece to be welded was placed on a table and connected to the positive side of an electric circuit, the negative side being connected to a carbon electrode, held in the hand of the operator, the arc being established by bringing the carbon into contact with the work piece on the table, then, effecting the proper separation to maintain the arc. It is thus seen that what is today known as "arc welding" was the first method used in electric welding. This process has since been developed to a high degree, special apparatus having been designed and developed, both current generating and control to meet various requirements and conditions in the manufacturing field.

In leading up to the subject of the evening, viz., "Electric Butt Welding," and in order to distinguish more clearly between the latter and the former processes, it may be stated that many of the socalled arc welding operations of today are fusing, rather than welding operations. Instead of a carbon electrode, as was used in the first welding operation cited, a metal electrode in the form of wire is much used, the molten wire being deposited on the work. In many cases this method is used in correcting surface defects of metal parts, the metal required to fill out depressions or voids being deposited from a metal electrode by means of an arc.

What is known as the Thomson process of electric butt welding was brought out in the year 1886 by Elihu Thomson. This method consists of passing through a closed circuit, of which the pieces to be welded together are made to form a part, an electric current of sufficient density to bring the work to a welding heat. To accomplish this it is necessary to so arrange this welding circuit with reference to conductivity that the sections to be welded form a high resistance point in the circuit, the energy in the electric current traversing this point will then appear in the form of heat.

The area of electric butt welding may be said to have begun with the perfecting of the automobile, the development of this industry to its present-day proportions and its volume production having brought out a wide range of applications which in turn have formed a basis for the establishment of many factories for the purpose of engaging in the welding business. Today this process is used extensively in the metal industries in the uniting of forged parts into one complete part which would be impracticable to make in one forging, the uniting of forgings to tubular and rod parts; welding wheel rims and bands, and so forth; high carbon and alloy steels, welding the longitudinal seams of formed steel tubing, uniting of dissimilar metals, as steel and brass. The adaptation of this process to the welding of formed tubes, dates from the year 1895, the experiments and development of equipment for doing this work having been carried out in Cleveland, and this process of welding tube was patented by a Cleveland man. Sometime later

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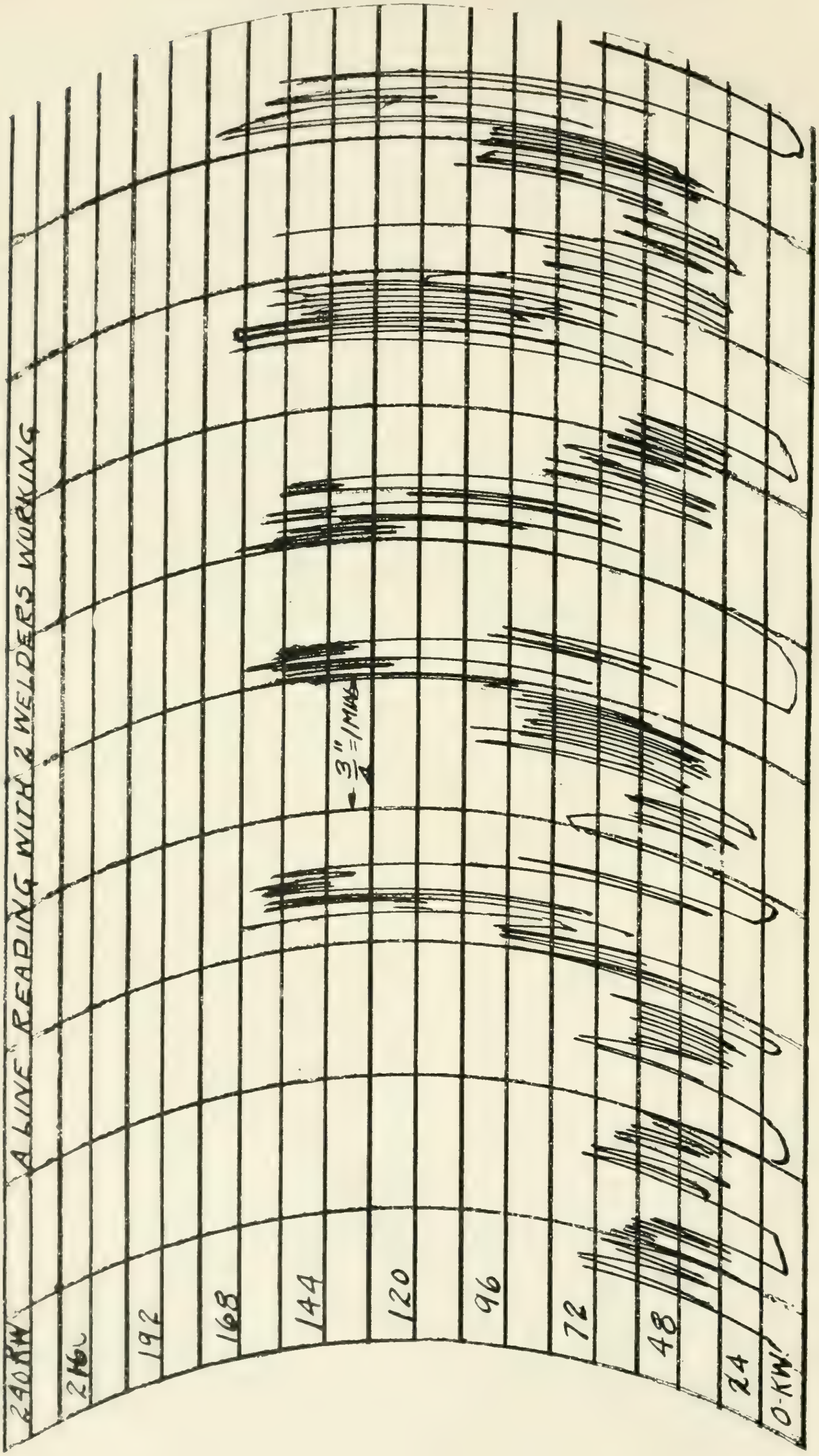
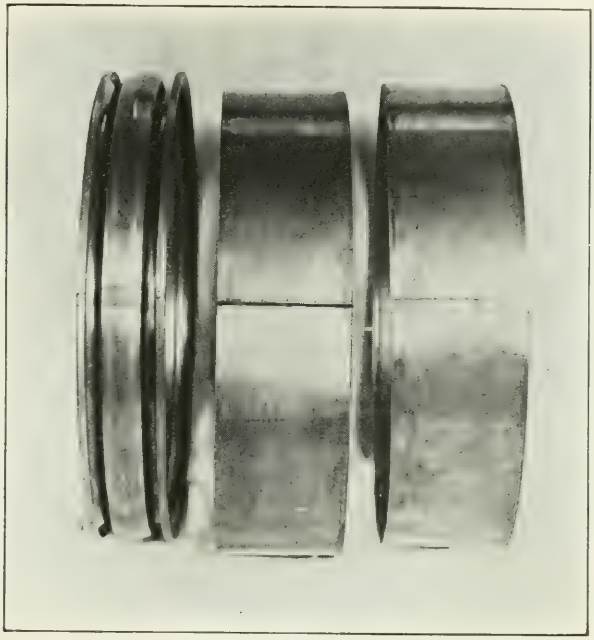


POWERGRAPH FROM FEEDER SUPPLYING TWO WELDING MACHINES

The Standard Welding Company, now one of the constituent plants of The Standard Parts Company, was formed for the purpose of manufacturing electric welded tubing, and gradually developed the business to its present day volume of millions of feet per month, in sizes of ⅛-inch to 3-inch diameter and in wall thicknesses of No. 20 to No. 11 U. S. S. gage, and in any length desired.



Rim Before and After Welding and Forming

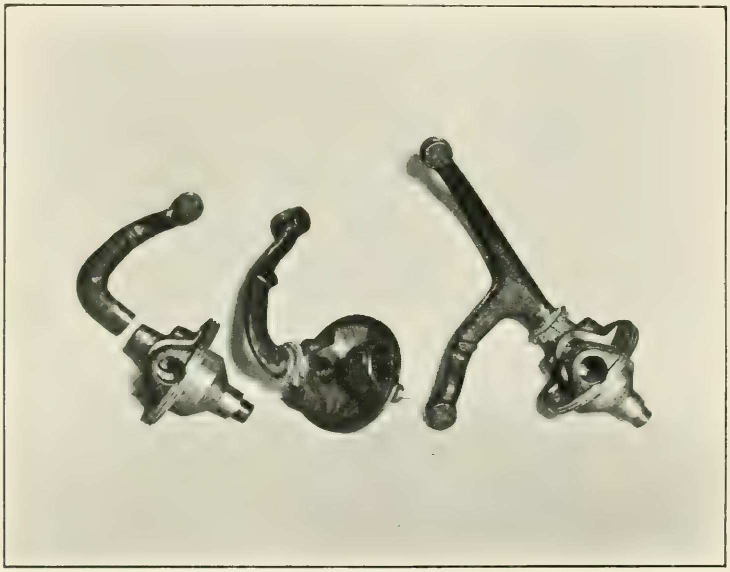
In localities having an available source of electric power, the establishment of a parts welding plant is comparatively simple. A complete electric butt weld, in bar or its equivalent, welding, comprises three operations. (1) Polishing that portion of the work pieces to be inserted in the welding machine clamps. (2) Welding the parts together. (3) Removing the burr or flash left after welding.

In some cases this burr is not objectionable and, therefore, need not be removed. In other kinds of work the sections to be welded together are such as to require another operation, prior to welding, as for instance, the uniting of a solid section to a tubular section, in which case it may be necessary, in order to make a perfect weld, to recess or countersink the solid part to conform to the tubular section.

In localities such as Cleveland, a small floor space in which were installed an emery wheel to be used for the first operation, a welding machine connected to a metered power service feeder for the second operation, the emery wheel also to take care of the third operation, would constitute a plant ready to take on some welding business. Such an enterprise would hardly be feasible in localities having no electric power source available.

To install power generating equipment for the simple plant cited would double, perhaps treble, the investment required. The character of a welding load is such as to require a high power capacity with a low hour's use of the capacity demand, this being par-

ticularly true when several machines are taking current from the power line. A powergraph taken from such circuit will consist of a series of jagged peaks. With an increased number of welding machines working, the diversity of the load will have the effect of filling in the interstices between the peaks, thereby increasing the hours use, without increasing the kilowatt demand proportionally.



WELDED STEERING AXLES

The essential elements of an electric butt welding machine are four in number. Assuming that alternating current is to be used, which is usually the case, they are:

(1) A transformer to convert the line current from a comparatively high voltage and low amperage, to a correspondingly high amperage at a low voltage.

(2) A means of connecting the pieces to be welded together, into the secondary circuit of the transformer.

(3) A means of making and breaking the primary circuit of the transformer.

(4) A means of forcing the work pieces together when at welding heat.

The transformer is similar in electrical design to those used in power distribution systems, its construction, however, differs considerably from them, the secondary usually consisting of a single turn which may be of either built-up copper ribbon, or of copper casting. The pieces to be welded are connected into the secondary circuit of the transformer by clamps, usually arranged for quick operating in order to facilitate the work. This is important as otherwise the time consumed in setting up the work and removing it from the machine, after welding, would be greater than that consumed in making the weld; this in some cases holds true, notwithstanding. These clamps may be arranged for either manual or mechanical operation; in the latter, either compressed air or water pressure may be used.

For making and breaking the transformer primary circuit, a quick break switch is used. This may be of special design to operate with a foot pedal or it may be a magnetic switch operated with a master switch. This latter makes a very convenient and safe arrangement. For affecting a union of the weld pieces at weld heat, one of the clamps is so arranged

as to be movable through a distance which may be made adjustable, the other clamp being fixed. This clamp's travel, which is very short, may be effected by either manual or mechanical means. For small section welding a hand lever is usually employed. Machines for the heavier welding are arranged for accomplishing this movement with hydraulic power, pressures up to several thousand pounds per square inch being employed.

Welded Gear Rings

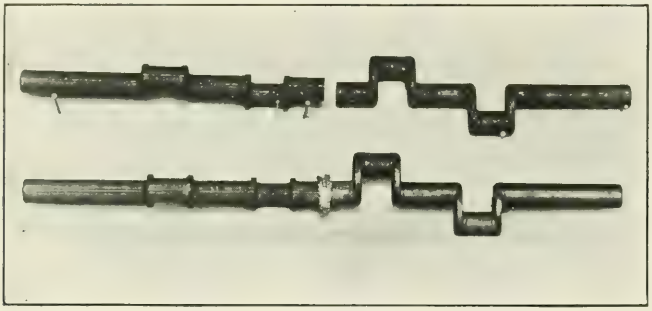
In general, the better welds are made by bringing up the heat quickly, on the other hand sufficient time must be allowed to run the heat back a little ways from the joint. The importance of this will be understood when it is considered that butt welding is essentially an upsetting operation. In making a weld, the cycle of operations is as follows:

Insert pieces to be joined in machine clamps, bring them into a butting relation, apply the clamps, apply pressure to movable clamp, close transformer circuit switch and run up heat by continued pressure on the movable clamp, form the upset. release pressure on movable clamp, release clamps, remove work from machine. In medium and small section welding, this sequence of operations is accomplished in a remarkably short period of time. Machines may be arranged to accomplish all of these operations automatically. So far as the welding operation is concerned, it could be done equally as well with direct current of electricity as with alternating current were it feasible to generate and transmit the very heavy densities of current required. This is made simple by the use of a welding transformer with its one turn secondary and many-turn primary winding. The voltage at the welding clamps may be varied within the range of approximately 2 to 6 volts. The resistance of pieces to be welded being low, the currents are of very large values, and may be upwards of 20,000 amperes. Such currents, to be transmitted without an excessive loss, require conductors of large section. The welding machine is so arranged with

reference to the relative positions of the transformer and the welding clamps, as to secure the shortest possible circuit for the welding current. The welding transformer may be arranged for either air or oil cooling. The cast secondary of the air-cooled type is usually rectangular in form and may be of either rectangular or T section. In the oil-cooled type the secondary is of hollow rectangular section.

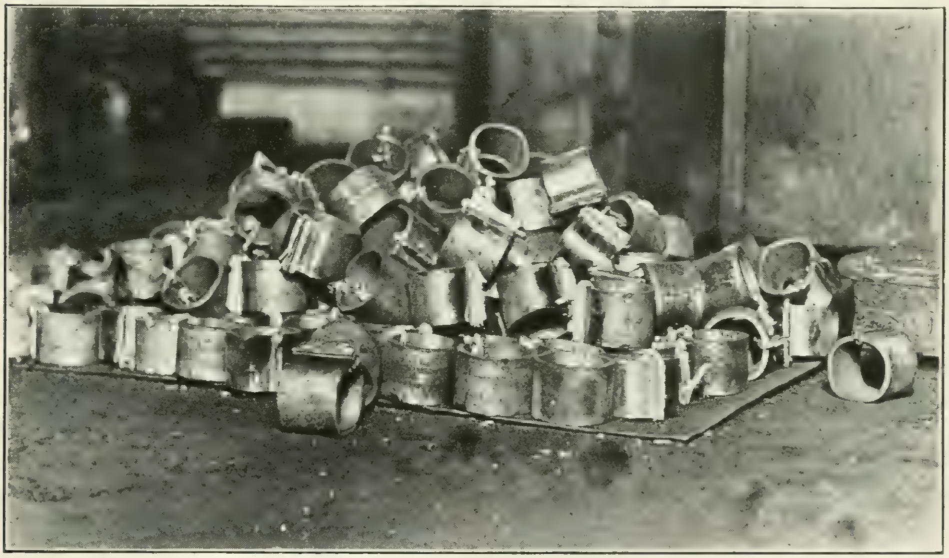
It is in some cases desirable to cool the oil in the transformer case by circulating it by means of a pump through a cooling coil submerged in water. The heating of the transformer is due not only to the current, but it also absorbs heat from the welding clamps by conduction. These become quite hot on account of the repeated welding heats between them. Water cooling is resorted to for removing this heat. The clamp die blocks, also the transformer terminals, have holes drilled in them through which a circulation of cool water is maintained. This process of welding lends itself admirably to modern demands of volume production. The equipment of a large welding plant makes possible the welding of various sizes, shapes, and so forth, of work at the same time, each machine being set up for a particular job which in many instances runs to several hundred and in many cases to thousands of pieces to be welded. In straight run production, as for example, in a factory making rims for motor cars, trucks, bicycles and motorcycles, this is particularly true. Starting an order of 50,000 rims is not unusual. Several welding machines would be set up for this order and the work run through rapidly.

The question of strength of the electric butt weld is sometimes raised. While all welds so made are not perfect in all respects, nor perhaps as strong as the section in the solid, yet the work has proven to be very satisfactory and but a small percentage is rejected on account of inferior welding. An example of a severe test for an electric weld may be cited in the ordinary steel rim for rubber tires. For example, the clincher rim may be considered. This is formed from a straight bar of steel into a ring and made endless by welding, after the burr-removing operation the clinch is formed. This clinching is conceded to be a very severe test of the weld and will usually remove any doubts from the mind of a prospective customer witnessing this operation. Electrically welded tubing is also regularly tested for weld strength. An initial test is made immediately after welding by cutting test pieces from each lot welded and expanding them by forcing them over a tapered mandrel. The processing of this tube, such as drawing, bending, swaging, and so forth, will also show up defective welding. While butt welding work may be done to conform to certain overall dimension limits of the welded piece, practically



CRANK SHAFT BEFORE AND AFTER WELDING

no attempt is made to work to absolute dimensions. In the forming and welding of rims, bands, and so forth, the ring after welding will only approximate the finished circumference dimension. In ring welding work it is therefore necessary to put the rings through a sizing operation, which may be accomplished by either shrinking or stretching. Except on the heavier sections this sizing is done with metal cold. The stretching operation is an excellent test of the weld.



Welded Magneto Rings

In the making of electric welded tube, the forming and welding is done to base dimensions, the finished size being produced by drawing or swaging.

In practice it is often desirable to add to the length of a piece of steel, shafting, or perhaps cut off a worn section and weld on a new piece. To insure a true running shaft, the practice is to weld on a piece of larger diameter than that of the section to which it is joined. This is then put into a lathe and turned to size. The butt welding of tube seams presents difficulties not encountered in the ordinary joining of parts. A specially designed machine is used through which the formed tube is passed, the welding being accomplished while the tube is in motion. The speed with which the tube is fed through the machine may vary between 6 feet and 18 feet per minute, depending on the thickness of the metal. The heat on the tube requires close attention on the part of the operator and is subject to his control.

The machine electrodes are copper discs, varying in diameter from 12 to 15 inches. These make contact with the tube on either side of the seam and revolve idly though under considerable pressure upon it. Their contact faces become rough and require refacing at frequent intervals, a special tool being used for the purpose. It will be readily understood the contact thus formed is of necessity variable which in turn results in a fluctuating heat at the weld, and as nothing has yet been devised to automatically control the heat, the results to be obtained depend to a very large degree upon the skill and the attentiveness of the operator.

Removing of the burr after welding is necessary except in a few instances. The inside burr in welded tubing is,

for some kinds of work, not objectionable and may be left in. This burring operation may be accomplished in several ways. It is removed from tubing by passing the tube under several cutting tools and finished by grinding. Rod work is put in a lathe and turned off. The burr may be removed from bar welds by either a burring tool or a gas flame.

The amount of energy consumed in welding varies according to the conductivity of the metal, size and shape of section, etc. Other factors such as the condition of the machine, the contact at the clamps, pressure at the weld joint both electrical and mechanical, also affect the power consumption. In general it may be stated that the more rapidly the work is done the less energy will be used.

The following outline of the history of electric resistance welding is given by the Thomson Electric Welding Company of Lynn, Mass.:

The Thomson process of electric resistance welding, like many other now well known technical arts, was discovered quite by accident and not by elaborate research as is commonly supposed. There is an old saying that "necessity is the mother of invention" and while this old axiom did not directly cause the accidental discovery of the process, it did serve to convey immediately to the discoverer's mind at the time how his newly discovered phenomenon could be used commercially to great advantage.

About the year 1885, Prof. Elihu Thomson, then connected with the Thomson-Houston Electric Co., of Lynn, was working more or less intently perfecting the design of electric generators. In making the coils for these early machines they were seriously handicapped by the fact that the copper companies could not supply wire in long enough reels to even wind one coil without having one or more joints in the coil. These had to be brazed or soldered and taped up afterward, presenting insulation difficulties at the joints when coils became hot in operation of the generators and prevented strictly uniform shape of like coils. Prof. Thomson asked the copper rolling mills if they could not weld reels of wire together to give him longer lengths to work with and was advised that this was impossible by any known method at the time.

While giving a lecture on electricity in general at the Franklin Institute of Philadelphia, one evening, among other apparatus for demonstration purposes, Prof. Thomson had with him a large high-tension jump spark coil and also some Leyden jars. After showing how a long spark could be produced from the secondary terminals of this coil by applying an interrupted direct current at the primary terminals, he then thought of trying an experiment with this coil the other way around. Accordingly he arranged for one of his assistants to discharge several of the Leyden jars in series—thereby effecting a very high potential—through the secondary winding of the spark coil, while he held two wires together, end to end, which were connected across the primary terminals of the coil. After discharging the jars in this manner the professor found that he could not pull the wires apart that he held—they had become joined at the ends through the heating effect of the current passed through them—in short, the first electric weld had been made, quite unintentionally. However, since the wires that the professor held in his hands were copper, it immediately dawned on him—here was his solution to joining two lengths of copper wire together—electric welding.

Immediately after this discovery the professor started research work in real earnest to bring this new principle to a commercial form and soon produced the first practical welding machine, known as the "Jews Harp Welder", so called from the shape of the secondary lead. Unlike the present day construction, this first machine had a solid secondary of

one turn, but by reducing the cross section of the bottom of the U form, the ends on which the clamps were mounted could be moved together or apart enough to permit pushing up the stock in welding. The primary winding was a circular coil of many turns laid within the secondary, which, by the way, truly resembled a form of a Jew's harp, and the core consisted of many turns of iron wire around and through the primary coil, embracing also the secondary for its portion immediately adjacent to the primary winding.

The pressure on the work was effected by a spring, tending to draw the outer ends of the secondary together, the tension being varied by a hand-operated screw passing through the spring. On this machine commercial welding of copper wire in various sizes within its electrical capacity was actually done by the Thomson-Houston Co., and, while this first model has been laid away for exhibition only, it can still do its "stunt" if called upon during an exhibition.

After taking out a patent on his new process, Prof. Thomson soon realized that there would be a tremendous field for this machine beyond the demands of the Thomson-Houston Electric Co., and, therefore, since this company had its hands full at that time, the Thomson Electric Welding Co. was formed in 1888 to commercially develop, manufacture and market apparatus for adapting the Thomson process of welding to all lines of business coming within its scope. The art attracted a great deal of attention in the scientific world and was enthusiastically received after its merits had been practically demonstrated.

The first large industrial application of the new process developed in the period between 1889 and 1890, in the welding of copper and iron wire in long continuous lengths, which permitted the formation of any reel of wire up to a length whose weight was within practical handling limits. This quickly spread to the welding of wagon tires and hub bands, also wire hoops, and when the wagon manufacturers found out how simply the tire proposition could be handled they naturally looked around for more work in their product and soon began welding various forgings of the frame and body assembly. The requirements for welding dash frames for carriages developed the double transformer welder at that time, to facilitate the forming of T welds.

The bicycle industry soon found that welding could be used to good advantage in the construction of frames and parts. Also one of the largest makers of wire fence took up the process and in conjunction with the Thomson Electric Welding Co. soon producd a machine that would turn out wire fence with all welded joints complete, from merely spools of wires being fed into it. About this time it was discovered that welding could be successfully used to join steel rails on street railway installations, making a continuous path of steel, which would not open up in the winter months nor yet buckle from expansion in the hot months. This also eliminated practically all effects of electrolysis in adjacent water and gas pipes.

With the arrival of the automobile, still greater fields have been opened to resistance welding in the various parts of motor construction. Since the opening of the world war, stringent economies in saving of both metal and labor have caused all manufacturers to look around for every possible process to aid them and electric welding by the Thomson process has certainly helped them out, no doubt, as much as any other new process. Perhaps one of the greatest savings effected is that of high speed steel, whose value has increased many times in the last few years, through the great demand for this metal on all machine work. The successful welding of high speed steel to lower grades of carbon steel was only made

possible commercially by the resistance welding method.

In every field within its scope where electric resistance welding has become a competitor of other processes of welding, it has been found more economical. Being free from objectional features of smoke, glare, soot and dirt, so common with other processes, a greater output per man could be obtained with less fatigue and less operating cost.

In later years, another radically different method of using the electric current has been discovered in the welding of sheet and plate metal as a substitute for riveting known as "point" or "spot" welding, opening a field even larger than that of "butt welding". The distinguishing features of the "spot" weld is that it is not intended to and does not weld the whole contacting area, but only the metal between the "points" of the electrodes; while in the "butt weld" it is intended and all the contacting metal is welded, the electrodes not being in contact with the welded portion at all. The product of the two processes is also very distinct.

"Spot" welding is largely used in household ware, interior finish of steel passenger coaches and in automobile bodies, sheet steel boxes and cabinets, steel furniture and an infinite variety of articles made from sheet steel, the number of these articles growing constantly.

There is another large field in which still another method can be employed in sheet steel working—namely in lap or seam welding of tubular or cylindrical forms and also plain sheets, especially thin sheets like coffee and tea pot bodies and spouts and a great variety of articles made from thin sheets where a seam weld is required. This weld might be distinguished by the name of "lap, seam or traveling weld". The old "butt welding" process has long been used in welding abutting edges of sheet steel of a thickness sufficient to use in tubing for mechanical purposes and for cylinders for kitchen boilers *et cetera.* This method might be described as "butt seam traveling welds".

The Thomson electric resistance processes are not only employed in the welding of the baser metals like iron and steel, but also in copper, brass and aluminum and the finer metals, welds being made in an infinite variety of forms and shapes of these metals which it would be entirely impracticable to weld by some of the other processes. The range in the bulk of such welds is well illustrated by the most delicate optical and jewelry work and the heaviest truck wheel base.

The machines employed also illustrate the wide range in the practice of the art, greatly varying as they do, in form and weight. Some of them weigh less than 50 pounds while others weigh over 9 tons. It is obvious that there can hardly be any points of resemblance between two such machines. The amount of current also required to operate such machines must also show striking contrasts. In the smallest machine, less than 1 kilowatt furnished all the power required, while in the largest, more than 250 kilowatts can economically be used, while making the welds.

As compared with most of the arts, the Thomson electric resistance process of welding is still in its infancy and, therefore, it can reasonably be expected to grow into even a much larger use than it has yet attained. Under these conditions, it would indeed be presumption to set any limit to its useful employment.

DISCUSSION

ED. LINDERS.—You spoke of the parts of the machine heating up considerably in welding. Isn't it due in part to a waste of electrical energy? Isn't there some way of controlling that and reducing the amount of heat?

J. B. CLAPPER.—Yes, I mentioned that. I also mentioned that a lot of that heat comes from the welding

heat itself. Of course, that is also wasted energy. Many schemes have been tried to control that, to minimize it, but those of you who have worked on welding machines have found out they are a very conductive machine to work with; they have to be thoroughly insulated, although the voltage on them is low. A lot of scale is continually accumulating on the conductors and around on the transformer, which if not cleaned off at short intervals, will result in energy loss.

J. C. LINCOLN.—What is the power factor of an installation requiring 10 or 20 kilowatts?

J. B. CLAPPER.—Somewhere between 60 and 65.

J. C. LINCOLN.—That is very largely due to the leakage of the transformer on account of the single coil secondary?

J. B. CLAPPER.—Yes, although it is pretty hard to get away from that.

J. C. LINCOLN.—Why would it not be possible to sandwich primaries and secondaries together the same as in a regular transformer and hold up the voltage?

J. B. CLAPPER.—How is that?

J. C. LINCOLN.—Throw a lot of the secondaries parallel instead of having a single secondary. That would make the magnetic leakage in that transformer very much less, and therefore the drop very much less.

J. B. CLAPPER.—It might have that effect. I do not know that that has yet been tried.

J. C. LINCOLN.—Would it be desirable to have that kind of an action where the voltage on the secondary is constant? As it is now the voltage on the secondary is high at low loads and low at heavy loads. Would it be desirable to have the voltage more nearly constant if you could get it?

J. B. CLAPPER.—It would, especially in welding tubes. It does not make so much difference in joining parts, for instance, where you do not have to exercise heat control so much. But in welding up the seam of a tube it does make a lot of difference.

J. C. LINCOLN.—In tube welding I suppose you get little recesses in the disc, and those recesses increase the resistance and decrease the heat. Is not that the action?

J. B. CLAPPER.—Your contact is varying all the time due to that.

J. C. LINCOLN.—When the contact is poor, of course the heat is low.

J. B. CLAPPER.—Yes. Those discs are under considerable pressure, and there is a tendency to form a little flash right on the edge of the disc, and the operator has to use a file continually as the discs revolve, to take that off. At short intervals the discs have to be taken out and refaced. That is done right along until the diameters of the electrodes are reduced to the minimum at which they may be used, when they are replaced by new ones.

J. C. LINCOLN.—Is that pressure applied through a spring?

J. B. CLAPPER.—No. The tube being formed up goes through a set of pressure rolls used for the purpose.

Q.—Is that tube rotated?

J. B. CLAPPER.—No, that tube passes through the machine lengthwise.

J. C. LINCOLN.—What is the diameter of the shaft where you carry the current on to those electrodes?

J. B. CLAPPER.—About 3½ inches.

J. C. LINCOLN.—Is that plain copper to copper contact, or do you use mercury in there?

J. B. CLAPPER.—Plain copper to copper.

Q.—Copper shafting or steel shafting?

J. B. CLAPPER.—Copper shafting.

J. C. LINCOLN.—Those discs are pressed against the tube in some manner. How do you get pressure against the tube? By a spring?

J. B. CLAPPER.—By springing the tube. The electrodes are adjustable up and down, that is, when they have once been set for a certain diameter of tube they are not adjusted while the tube is being welded. The pres-

sure is applied by the pressure rolls previously mentioned. If the current is interrupted for any reason, then the metal will overlap slightly. It has to go somewhere.

I. E. WAECHTER.—Do you ever use other metal than copper for shafts?

J. B. CLAPPER.—No.

I. E. WAECHTER.—For welding two dissimilar metals?

J. B. CLAPPER.—Well, we never try to weld anything like that on a tube welding machine.

I. E. WAECHTER.—In welding two dissimilar metals, say high speed and low carbon steels, one side of the metal will heat up quicker than the other, due to the different electrical resistance. There is a tendency of coarsening the grain on one side of the weld more than on the other. Don't you think it would be a good idea to use a die made of some other metal the electrical conductivity of which is less than that of copper for the low carbon steel side so as to leave the heat somewhat longer in the low carbon steel due to which it will heat up at about the same rate as the high speed will?

J. B. CLAPPER.—Of course, if you were to restrict your current at any one point in the circuit, it would be the same in both of the parts you are trying to join. You have to consider that in the section of the pieces you are trying to weld together. For instance, if you want to weld brass to steel, you leave the brass section larger than the steel on account of the resistance of the brass being so much lower than that of the steel.

Q.—In making welded tube, you have two currents. One through the joint and one through the tube. Can you make a test as to how much current goes through the tube?

J. B. CLAPPER.—Well, we have; it varies for different sized tubes.

Q.—You might weld a 1-inch and a 2-inch tube, and get two equations?

J. B. CLAPPER.—Of course, that will vary with the diameter of the tube and the thickness of the wall.

Q.—I believe with a series of tubes you might get the amount of current regulated for the arc, taking tubes say 1, 2, 3 or 4 inches in diameter. Of course, the current would increase as you increased the diameter of your tube.

J. C. LINCOLN.—Do you notice any difference in the loss in welding such a tube as that, due to the frequency? Of course, the current travels around the part of the tube that is not heated, which will produce an inductive resistance, due to the fact it travels in a circle, while current that travels from disc to disc is only useful current of course. Would high frequency tend to reduce the waste current? Do you notice any difference in 25 and 60 cycles?

J. B. CLAPPER.—We have never made any tests to determine that point.

Q.—In Welding a tube to solid shapes, is it necessary to core the shaft?

J. B. CLAPPER.—Not in all cases, no.

Q.—What would be the effect if you use a solid shaft; what kind of a burr would it form?

J. B. CLAPPER.—You would run the chance of getting a defective weld.

Q.—You could melt your tube?

J. B. CLAPPER.—Yes, without getting a heat on the solid part.

J. C. LINCOLN.—How much larger is it possible to have one electrode than the other and still do satisfactory work?

J. B. CLAPPER.—I do not know as there is any definite relation there. There may be, but we have never tried to determine it.

J. C. LINCOLN.—Of course, the case you just spoke of is one case where one electrode is much larger in section than the other, and you do not get a satisfactory weld.

J. B. CLAPPER.—Yes.

J. C. LINCOLN.—And I presume that you would not have to have exactly the same area on both the elec-

trodes to be welded. You could have some difference?

J. B. Clapper.—Oh, yes.

J. C. Lincoln.—I was wondering what the commercial limits were in area of the two pieces to be welded.

J. B. Clapper.—I should say you could vary that from 10 to 20 per cent and still get a weld that would be quite satisfactory for most classes of work.

J. C. Lincoln.—Not much over 20 per cent then would be your opinion?

J. B. Clapper.—No.

Q.—Alternating current is simply a matter of convenience in transmitting the current to the point to be welded?

J. B. Clapper.—That is all.

Q.—What method do you use for equalizing your load? If you had a number of welders on the same circuit, if they were all welding at the same time and throwing off at the same time—I have known three welders to shut down a good sized Corliss engine. I wondered how you equalized that.

J. B. Clapper.—We don't.

Q.—It all depends on the good nature of the men that are doing the work?

J. B. Clapper.—Yes. They don't all try to work together, you know.

Q.—I have seen them shut down a good sized Corliss engine by bunching them up that way.

J. B. Clapper.—We have often blown our circuit breaker.

Q.—Have you seen or gathered any data upon electric welding of the engines on the interned German boats?

J. B. Clapper.—The only thing I know of is what I read in the newspaper last night, that electric welding was used in hastening the work of repairing the broken machinery of the interned boats.

Q.—They claim it was done in a month's time.

J. B. Clapper.—I have wondered myself just what they welded on those machines.

Q.—Is it safe to weld large cast iron pieces with that process? Would the initial strain be too much?

J. B. Clapper.—Yes. I do not think it would be practical to do that.

Q.—In welding copper to steel; I have in mind rail bonding. Direct current would be more desirable for that work than alternating current, would it not?

J. B. Clapper.—Well, in general it would be more desirable for any kind of welding work.

Q.—In driving back the burr on the stock that is thrown up in welding, what effect does that have on the strength of the weld?

J. B. Clapper.—We do not drive it back; we remove it.

Q.—You have to remove it all?

J. B. Clapper.—Yes.

Q.—If you drive it back it weakens the weld; is that the idea?

J. B. Clapper.—You would not gain strength, because that metal that comes out is usually burned metal. You would not gain anything by trying to drive that back in. You would, I think, weaken your weld.

Q.—Now, if you were welding a black stock without being brightened, it increases your current?

J. B. Clapper.—It increases your resistance. Your heat will come up slower, unless you apply more voltage, of course.

Q.—The welding jaws, the longer the copper wears the harder they become in the dies themselves.

J. B. Clapper.—I imagine they do, yes.

Q.—They should be kept very bright?

J. B. Clapper.—Yes. Not that they are kept that way. I do not mean to say they are, but it would have a beneficial effect if they were kept bright.

Q.—I will say under that head that the general manager of our plant always insisted they be bright, and the upkeep comes under me. I know they do not keep very bright, but

they seem to do good work, and that is the reason I raise the question.

J. B. CLAPPER.—I have seen them so that it would be hard to distinguish between the cast iron and steel and the electrodes, unless you took a file and dug in a little bit.

Q.—What is the comparative cost of welding tubing electrically and by gas? You take the same sized tubing, 1½ by 18 gauge.

J. B. CLAPPER.—Well, just the welding operation itself, it is much cheaper to electrically weld it, but considering the fact you have to remove the burr on electrically welded tube, it makes it about 50-50, the finished tube. Also, with the electric weld you can weld from three to four times the speed you can with the gas weld.

Q.—I don't see why you don't get a burr on the inside of your tube as well as the outside.

J. B. CLAPPER.—We do.

Q.—How do you get rid of that?

J. B. CLAPPER.—It is taken out while the tube is drawn; in some cases you can get a tube with a burr in cheaper than with the burr removed. When they call for a burr in tube, we do not take it out, but in case we do have to remove it we do so while we are drawing the tube. Any tube has to be drawn to size and gauge. That tube is drawn through a die. There is a triblet inside of the tube which determines the inside diameter and also the gauge of the stock after the tube passes through the die. It is held on a long rod over which the tube is stripped before it starts through the die. On this tool there is a cutting edge which removes the burr. The tube is reduced in diameter and burred at the same time.

J. C. LINCOLN.—Why would not it be possible to take the outside burr off in a similar manner?

J. B. CLAPPER.—It can be done quicker with a specially arranged burring machine.

J. C. LINCOLN.—Removing the burr is quite an expensive operation?

J. B. CLAPPER.—It is.

J. C. LINCOLN.—It costs as much to remove the burr as to do the welding. You spoke of the comparison of cost of electric welding tube and gas welding tube. You said removing the burr brought the cost of one about equal to the other.

J. B. CLAPPER.—Finishing up the burr is what brings up the cost of the electric welded tube.

C. O. PALMER.—Is not the tube stronger when the burr is left on the inside?

J. B. CLAPPER.—That depends on the quality of the weld. Of course, taking the burr off will open up perhaps some spots in the weld where there are little defects, which would of course leave weak points. Leaving the burr on there would have a tendency to overcome them, in other words, leave strength there and help to make up for a little deficient welding.

J. C. LINCOLN.—Take 1/16-inch tube; how high is that burr?

J. B. CLAPPER.—About 1/16-inch.

J. C. LINCOLN.—Possibly the thickness of the stock on each side?

J. B. CLAPPER.—Yes.

A. F. BLASER.—You made the statement that a rail laid end to end would behave all right either in winter or summer. What is the explanation of that?

J. B. CLAPPER.—I didn't make that statement. I quoted the Thomson people on that.

A. F. BLASER.—It was in your paper.

J. B. CLAPPER.—Yes. I would like to know that myself. I have asked that question in times past. I do not see that the weld would have anything to do with it.

J. C. LINCOLN.—The fact of the case is that particular weld is made by welding the fish plate to the rail?

J. B. CLAPPER.—Yes. It has the effect of making a continuous rail.

J. C. LINCOLN.—It is a continuous rail effect.